REPORT

OF

STUDY GROUP

ON

AGRICULTURAL STRATEGIES

FOR

EASTERN REGION

OF

INDIA

GOVERNMENT OF INDIA
PLANNING COMMISSION
JULY 1985

CONTENTS

FOREWORD

The eastern region comprising Assam, Bihar, east Madhya Pradesh, Orissa, eastern Uttar Pradesh and West Bengal have been lagging behind the rest of the country in respect of agricultural performance. The gap between the actual output and the potential that can be achieved with the known technology is very high in this region. This region also accounts for a very large part of the population below the poverty line in the country. The agricultural development of this region apart from contributing to self-reliance on sustained basis would also raise employment and incomes for the poorest of the poor in the country. The complementarity between growth and equity is no where as pronounced as in this region.

It is with this concern that the Planning Commission constituted the present Study Group to review performance in respect of major food crops in the eastern region, identify constraints and possibilities for growth and suggest an outline of strategy for achieving rapid growth. This endeavour has proved to be rewarding because of fruitful collaboration between the perspective Planning Division of the Planning Commission and a number of distinguished experts from the concerned Ministries as well as academic institutions. The field visits undertaken by the Members of the Group provided important insights into the problems at the grassroot level.

The Report shows that some of the regions in the eastern belt have shown encouraging performance, particularly in respect of wheat. However, the Report brings out the problems of waterlogging and salinity in large tracts of land where yields have come down substantially in the course of the last two decades. The study shows that there is a significant potential for raising agricultural output if farmers' resource position is strengthened, the various uncertainties facing farmers are reduced, new varieties of seeds and improved practices are evolved to suit different agro-climatic conditions and infrastructure, both physical and institutional, is provided.

Water management emerges as a key factor in the development of this region. There is need to undertake drainage schemes at local levels. In many of these regions as much as 80% of the available groundwater potential remains untapped which can be exploited through public as well as private tubewells at a relatively low cost. Construction of field channels would help to utilise more productively the large irrigation potential already created, with a little additional cost. These activities offer vast scope for integrating poverty alleviation programmes like IRDP, NREP, RLEGP, etc., with programmes for increasing agricultural productivity.

This strategy is also likely to be cost-effective because of the generally low wages prevailing in the area, abundance of groundwater availability which can be tapped at relatively low cost and a high response of output to fertilizers. There is a growing awareness among farmers in this region about the improved methods of cultivation and they have shown readiness to take to new practices for increasing production.

While the prospects are encouraging, the options are by no means soft in the short and the medium-run. The investments required to develop the infrastructure are going to be substantial, particularly because the availability of infrastructure in this region is significantly below the national average. Revamping of credit institutions and development of regulated markets are essential for increasing the incomes of farmers through the elimination of exploitation by the middlemen. This would also provide incentives and resources for higher investment. All these tasks pose major challenges to development administration. There needs to be a reorientation of approach on the part of the implementing agencies towards building institutional infrastructure and paying greater attention to sharecroppers and small and marginal farmers in the provision of extension services, allocation of inputs and credit, etc., so as to increase their incomes and induce them to participate more fully in the overall developmental process.

It is with these objectives in view that the Government of India had initiated a pilot project for increasing rice production in 1984-85 in 51 blocks in the six eastern States. The experience has been encouraging in respect of participation of the respective States, response from the farmers and the increases in rice yields achieved in these selected blocks. Based on this experience, it is proposed to

extend this special programme for increasing rice production to 20% of blocks in each of these regions in the course of the Seventh Five Year Plan. Efforts are underway to prepare block-wise Plans in the light of the constraints identified. It has also been decided to integrate the special rice production Plan with the overall agricultural development in the areas concerned by easing long-term constraints through the development of physical and institutional infrastructure.

The Report is being published with the hope that it would evoke interest among policy-makers, administrators, academic community and the public at large in this vital area of concern in our national planning. I hope that the Report will stimulate further interest for undertaking detailed analysis of the constraints to agricultural development and for exploring cost-effective possibilities of increasing agricultural output in the eastern region.

C.H. HANUMANTHA RAO

Member

Planning Commission

July 17, 1985.

PREFACE

In the Seventh Five Year Plan (1985—90), a comparatively high priority has been assigned to a faster growth in the foodgrain production in the Eastern India, comprising of Bihar, East U.P., Orissa and West Bengal. It is emphasised that in order to increase equity and reduce poverty, more emphasis has to be given to the generation of additional purchasing power among the poors and the increase in the available food supply. In view of having a high potential but a low productivity in the eastern sector and the existence of a large number of small and marginal farmers below the poverty line, it is recommended that a concentrated effort should be directed towards increasing the productivity and production in the Eastern region of India. Accordingly, an expert committee was formed to probe into this area.

This report analyses the productivity and their changes for agriculture and separately for rice and wheat in the Eastern region. The potential yield rates of rice and wheat vis-a-vis present levels in this region, has been estimated. The committee found that there is a vast gap between the potential and the actual production in these crops in the Eastern region.

Dr. Padam Singh, Joint Adviser, Perspective Planning Division and Member-Secretary of the Study Group was responsible for overall coordination. Without his help this report would have been difficult to complete. Shri Ahluwalia, Deputy Adviser (PP) acted as Member-Secretary and coordinated the work for a short period when Dr. Padam Singh was away. For developing different chapters, Dr. (Miss) Kusum Chopra, Consultant (PP); Dr. P. Rangaswamy, Consultant (PP); Dr. G.R. Saini ESA; Dr. K. Subbarao, Professor, I.E.G.; Dr. P.N. Bhargava, I.A.S.R.I., Dr. M.P. Gupta, Deputy Adviser (PP) and Shri V.K. Rajagopalan, Deputy Adviser (PP), gave valuable contribution and support. The data compilation, scrutiny and its computerisation; computation/estimation and tabulation work was supervised by Dr. V.K. Malhotra, SRO with the help of Shri R.P. Nagi, Research Officer. Sarva Shri R.K. Sonkar and Ajit Singh, Research Officers of the Perspective Planning Division also contributed to the preparation of this Report.

The programming work was undertaken by Shri R.K. Pruthi and Shri M.R. Rao, two Senior Programmers working with Perspective Planning Division. They have been ably assisted by Sarva Shri P.C. Aggarwal, Karan Singh, S. K. Chawla, Programmers, Sarva Shri S. Natarajan, Ram Babu, M. Mukhopadhyay, and S.S. Wadhwa Investigators, S/Shri V.K. Jain, Mohinder Singh, S.P. Nagal and Damodar Bawari, Computers of Perspective Planning Division also helped in collection of data from various published sources.

Last, but not the least, our gratitude to Dr. Daroga Singh, Ex-Director, IASRI, for his help in our field work and analysis.

S.P. GUPTA
Chairman,
Study Group
on Agricultural Strategies
for Eastern Region of India

July 7, 1985

SUMMARY

1. Agricultural Productivity

The classification of districts by productivity level in the eastern region revealed that 26 out of 60 districts were in the low productivity range in 1970's of which 9 each were from Bihar and Orissa, 7 from East U.P. and 1 from West Bengal. Of these 26 low productivity districts, 15 had moved into medium productivity range by 1980's. Of 11 not moving upwards, 7 belonged to Bihar, 3 to Orissa, and one to east U.P. Further, 25 districts in 1970's were in medium productivity category of which 6 belonged to Bihar, 4 to Orissa, 8 to East U.P. and 7 to West Bengal. Of these 25, 14 moved into high productivity range. Of the 11 remaining in the same category, 5 belonged to Bihar, 4 to West Bengal, 1 to East U.P. and 1 to Orissa. In 1970's the eastern region had only 9 high productivity districts. While 8 remained in this category in 1980's, 1 came down to medium productivity category. Since other medium productivity districts of 1970's recorded upward mobility, the total number of districts in high productivity category rose to 22 by 1980s.

Further, the classification of districts by growth rates of agricultural productivity showed that more than 90% cultivated area in Eastern U.P. and about three-fourth in Orissa is operating under medium and high growth rates while nearly three-fourth in Bihar and two-third in West Bengal is operating under negative or very low growth rates. For the eastern zone as a whole nearly 40% of the cultivated area is operating under negative or very low growth rate.

Many of the identified low and negative growing districts of the eastern region happen to be upland or hill districts where the level of irrigation happens to be very low. But what is more disheartening is poor growth performance of the districts of Bihar particularly of the Ganga plains including Gaya, Patna, Monghyr, Shahabad, Bhagalpur, Saran and Coastal districts like Puri and Ganjam of Orissa where not only the level of irrigation is high but has also increased substantially during the past decade. As opposed to this, some less endowed districts like Palamau, Muzaffarpur and Purnea of Bihar and the upland districts of Orissa have performed well.

As to the determinents of productivity, the most important variable explaining inter-district variation in productivity within each category turns out to be fertilizer consumption per hectare. As between the three categories of districts, there are differences with respect to determinents of fertilizer consumption. In the low productivity districts, fertiliser consumption appears to be demand-determined, being explainable by the quantity and quality of irrigation and soil rating index. In the medium productive districts also the fertiliser consumption is influenced by quantity and quality of irrigation. In the high productivity districts fertiliser consumption is influenced primarily by the supply-side factors, viz., access to fertiliser retail outlet, credit institutions, rural road network etc.

2. Productivity of Rice

The average yield for the region (1034 kg/ha) is around 3 q/ha less than the all India average during 1980—82. Of the four Eastern Region States, West Bengal has the highest average yield of rice (1280 kg./ha.) which is however, 42 kg. less than the national average. The yields of the other three states are just between 9 and 10 q/ha. The growth rates in yields between 70's and 80's have also not been satisfactory in the region except for east U.P. which has achieved a growth rate of 2.0%. In Bihar as well as West Bengal the average growth rate was very low (less than 0.5%) indicating a stagnancy of yields at a low level in Bihar and at a relatively high level in West Bengal. Orissa had a slightly higher growth rate (1%). The average growth rate for the eastern region is just 0.8% compared to 1.8% for all India. The district-wise distribution of yields shows that all but one district in Bihar are in the low and medium yield ranges (4 to 12 q/ha), while in Orissa and East U.P. all or most of the districts are in the medium range (8 to 12 q/ha). In the case of West Bengal the districts are distributed in the medium and high yield groups.

Super-imposing the growth rate categories on the yield groups, it is seen that most of the districts are in the high yield-low growth categories in West Bengal, in the medium yield-high growth categories in East U.P. in the medium yield-medium growth in Orissa and in the low to medium yield-low growth groups in Bihar.

One major reason for the low yield levels of eastern region States compared to the rest of India, particularly the chief rice growing southern states viz., Andhra Pradesh and Tamil Nadu is the much lower level of irrigation in the former. About three-fourths of the rice area in the eastern region is still cultivated under the uncertain monsoon conditions affected by floods as well as droughts.

The inter-State differences in yield within the eastern region are not, however, explained by irrigation alone. In spite of Bihar being better placed in respect of irrigation its yields, level is low whereas that of West Bengal is much higher, though its irrigation ratio is lower. This means that irrigation management is as important as the creation of irrigation potential.

Flooding and drainage problems are quite serious in the eastern region which prevent an optimal utilisation of the available irrigation potential. There are also other problems like saline and alkaline soils found over large areas. The eastern region is lagging behind the rest of India in the HYV coverage which is less than 31% in three States viz., Bihar, West Bengal and Orissa.

Technological advaneement with regard to rice has not been as impressive as in the case of wheat. Lack of suitable varieties for the flood prone low lands has been a major constraint to increase in productivity. Fertilizer use is not quite profitable under flood prone

or drought-prone conditions. Eastern region is also deficient in infrastructural facilities like roads, availability of power, credit, sale outlets for seeds, fertiliser etc., which hamper the spread of even available technology. Low farm harvest prices and absence of regulated markets are another major disincentive for the farmers to adopt the costly inputs. Institutional factors like small size of holding, its fragmentation and widespread incidence of sharecropping also act as constraints to the intensive use of modern inputs.

3. Productivity of wheat

The average yield of wheat in the eastern region during 1980—82 was 14.3 q/ha. compared to 16.6 q/ha. for all India. The productivity of wheat, however, is 4 q./ha. more than that of rice in the region due to better technological advancement and its cultivation under controlled water supply in the rabi season.

The yield levels of wheat are comparatively higher in Orissa (18.6 q/ha.) and West Bengal (17.4 q/ha.) than in Bihar (13.3 q/ha.) and east U.P. (14.5 q/ha.). This ranking is more or less similar to the case of rice, except that the first and second position have been reversed. The distribution of districts by yields suggests that most of Bihar districts are in the low yield category 14.00 q/ha. while most of east U.P. districts are in the medium yield group (14 to 18 q/ha). Almost all the districts in West Bengal and Orissa belong to the medium and high yield groups.

Regarding the rates of growth in wheat yields between the 70's and 80's east U.P. has again performed best, as in the case of rice, achieving a growth rate of 3.5%, while Orissa has a modest growth rate of 1.4%. In contrast West Bengal and Bihar had negative growth rates (—1.4% and—0.5% respectively). The distribution of districts also shows that majority of the districts had growth rates above 2% in east U.P., while in Orissa, growth rates ranged from 0 to more than 2%. In contrast West Bengal had two-thirds of the districts with negative growth rates while most of the districts in Bihar had either negative or low growth (below 2%). The growth rate in the eastern region as a whole has been only a low 0.9% compared to 2.2% for all India.

Combining growth rates and yield levels, it is observed that a large number of districts in West Bengal, belong to medium to high yield-negative growth categories, while most of Orissa districts are in medium to high yield-low to high growth groups. On the other hand, districts in east U.P. are largely in the medium yield-high growth groups while Bihar districts are mostly in low yield-negative to low growth categories.

In contrast to the low level of irrigation for rice in the region (only 25% of the area is irrigated), the area under wheat is largely irrigated (81%). Only in West Bengal the irrigation percentage is very low (27%). Similarly HYV coverage also is quite high (77%) in the eastern region which is only 1% less than the percentage for all India. In Orissa and West Bengal where area under wheat is very limited, almost the entire area is covered by HYVs. In spite of such high input levels, the yields in the eastern region particularly in east U.P. and Bihar are lower than the national average, though in Orissa and West Bengal they are higher.

The productivity of wheat has been in general, higher than that of rice in the four eastern states, due to better coverage under irrigation and HYV. However, the area under wheat has been much smaller than that of the rice except in east U.P. where it is fairly close to the rice area. With the extension of irrigation the area under wheat is bound to go up. This will help to raise the cropping intensity in these States and lead to a relatively more diversified and profitable cropping pattern, neutralising to some extent, the risk element involved in placing too much emphasis on the rice crop which suffers from greater yield fluctuations. It will also help in absorbing more labour, family and hired, more gainfully all the year round. Above all, it will help the eastern States to participate in and share the gains of the wheat revolution now largely confined to Punjab, Haryana and West Uttar Pradesh. For the country also, this will be a big advantage in so far as wheat production will then have a much wider geographical coverage so that shortfalls in one area may be made up by gains in another. So while all efforts should be made to raise rice production in these areas, these should not be at the expense of wheat production.

4. The gap between the Actual and the Potential Yields

The potential in the Eastern Region has been estimated by two alternative approaches. In the first approach the results of experiments on cultivators fields specially obtained from Indian Agricultural Statistics Research Institute for the Study Group have been made use of whereas in the second approach the States of the region have been divided according to agro-climatic zones and in each zone, the average yield is then compared with the highest yield obtained in a district falling in that zone. This may not be the best choice but has been considered to arrive at an approximate and the immediate level of potential. The potential estimated using first approach can be achieved by proper extension taking the available technology to the farms whereas the potential estimated through second alternative can be achieved by providing infra structure and inputs at par with the best district in each agro-climatic zones.

It was observed through first approach that in terms of potential yields for rice, consistent with economic optimum, Orissa ranks first followed by Bihar. The same position holds in terms of gap between optimum yields and actual yields of rice. Further, through this approach it is also seen that the potential in Eastern Region, as a whole, is little over 400 per cent than the actual yields, as against the corresponding figure of 244 per cent for the rest of the country. For wheat the potential for Eastern Region has been estimated at 220 per cent which is highest as compared to other regions of the country. Further, the potential of wheat yield is highest for Bihar not only in the Eastern Region States but also in the rest of the country.

Through the second alternative it is seen that the eastern region has a potential of about 25% in the rice yields. The potential of yield is highest in East U.P. followed by West Bengal, Orissa and Bihar. Further, the potential in Eastern Region is about 38 per cent higher than that of Southern Region. For wheat the potential in the Eastern Region is of the same magnitude as that of northern Region.

5. Strategies for Raising Productivity

The following strategies would seem to be appropriate for eastern region :

(i) Land and Water Management

1. States should help in expediting the process of consolidation of holdings in order to accord viability to the economic management of holdings.

2. In States where sharecropping is prevalent, it may be regulated for promoting input-use.

3. Soil amelioration programmes in areas with problem soils like acidity in plateau regions, salinity and alkalinity in several east Uttar Pradesh and north Bihar plains districts, with financial assistance to small and marginal farmers. Chemicals for this purpose should also be made available at the doorsteps of the farmers.

4. Erosion control in the plateau regions of Bihar, Orissa and West Bengal through soil conservation programmes including terraced cultivation, afforestation on hilly slopes, pasture development on fallow or waste lands, intercropping, etc.

5. Speedy construction of field channels and drainage channels in the canal command areas of the four States, preferably in conjuction with land consolidation programmes. Regulated water supply in the commands by provision of shutters and other devices and introduction of Warabandi system to promote efficiency as well as equity in water distribution system.

6. Groundwater development programmes with emphasis on modern methods like drip and sprinkler systems in undulating areas of water scarcity and on energisation of pumpsets and tubewells. Financing and subsidising the construction of private tubewells, dugwells, etc., particularly for small farmers.

7. Tapping and/or fully utilising other sources like riverlifts, tanks, public tubewells, etc., at State expense.

8. More effective flood control measures in Bihar plains, especially in northern plains, coastal districts of Orissa and West Bengal and Gangetic plains in east Uttar Pradesh.

(ii) Technology

9. Research emphasis on drought and pest-resistant high yielding varieties for wheat.

10. Research emphasis on developing new paddy varieties more resistant to flood/droughts, and suited to low land/upland situations.

11. Promotion of inter-cropping of cereals and pulses/oilseeds especially on uplands.

(iii) Infrastructure and Institutions

12. Development of infrastructural facilities like roads, sale outlets for fertilisers, seed multiplication farms etc. to step up the supply and distribution of modern inputs equitably among different regions and different sections of the farming community.

13. Regulated markets may be strengthend so that the farmers are able to obtain remunerative prices for their produce.

14. Strengthening of extension system like T and V for more effective dissemination of research information and for cooperative control of pests and other problems.

15. Cooperative societies should be strengthened so that they are better able to supply credit to the farmers and market their produce.

CHAPTER 1

INTRODUCTION

The Eastern Region of India studied in this Report comprises of states of Bihar, Eastern U.P., Orissa and West Bengal. The Eastern Region accounts for about 15 per cent of geographical area and around 21 per cent of the gross cropped area. The distribution of gross cropped area of the eastern region among the states of Bihar, Orissa, Eastern U.P. and West Bengal is 31.2, 24.4, 23.0 and 21.4 per cent respectively. The cropping pattern in this region is very much different from that of the country as a whole (Table 1·2). The main crop of the Eastern region is rice which accounts for about 50 per cent of the gross cropped area as against only 23 per cent for the country as a whole. The share of area under wheat in this region is 13 per cent which is at par with the country as a whole. But, East U.P. and Bihar account for 93 per cent of the area under wheat in the Eastern Region. The share of area under other cereals and oilseeds in this region is very much on the lower side as compared to the country as a whole.

The States of the Eastern Region fall in the fertile Indo-Gangetic belt of the country and are interspersed with a number of rivers many of which are the tributaries of the Ganges. Because of the river system, a large part of the plains abounds in alluvial soil and has high land fertility.

The irrigated area as well as the fertiliser consumption in Eastern Region have recorded higher growth rate (during 1970—73 to 80—82) as compared to the country as a whole. The percentage irrigated area in the Eastern Region is of the same magnitude as that for the country as a whole. But the levels of fertiliser consumption is still lower than the average for the country.

Lately, it is observed that while the share of cultivated area in this region has increased marginally in the beginning of the decade of the eighties (20.6 per cent) when compared to the earlier decade (19.6 per cent), the share of agricultural production has declined somewhat. This region accounted for around 25 per cent of total cereal production in 70's which has declined to 23 per cent in the beginning of 80's (Table 1.3). Thus, the growth rate of cultivated area is higher in the Eastern Region when compared to India as a whole while the growth rate of yield is lower in the eastern region as compared to the average for the country.

Many districts of the Eastern Region are seen to be dominated by problems of chronic floods, drought-prone conditions, saline and alkaline land, soil erosion besides problems relating to drainage and water-logging. Floods affected nearly 6.2, 17.4, 1.5 and 1.2 per cent of the gross cultivated area in 1980 in the States of Bihar, Eastern U.P., Orissa and West Bengal respectively. Rainfall in the Eastern Region is seen to be highly variable, sometimes heavy rains leading to floods and sometimes scanty rain leading to drought.

The land main ratio is adverse in this region compare to the rest of the country since 29.23 per cent of total population live in Eastern region while the area under cultivation in Eastern region is 18.3 per cent of total cultivated area of the country. The pressure of population of land becomes more acute when it is noticed that not only the share of rural population (84 per cent) is higher in this region compared to the rest of the country (around 75 per cent), but the population involved in agricultural activities is also higher in this region compared to the average of other states. Cultivated land per capita is only 0.15 hectare in this region as compared to a figure of 0.25 hectares in the rest of the country. This acts as a genuine limitation to the resource position of the farmers.

The prevailing land distribution pattern is highly skewed. A much larger share of land is concentrated in fewer holdings. It should be noticed with concern that there is pre-ponderance of holdings below one hectare. Nearly 80% of the holdings fall in this category and this percentage increases to 90 if the holdings upto 2 hectares are considered. In Eastern U.P. 90.8% of holdings having only 34.6% of area under total holdings were small and marginal holdings in 1976-77. In Bihar more than four-fifths of total holdings are of the size of 2 hectares or less and they account for nearly 38% of the total operated area in the States. In West Bengal, 87% of the farmers are of the small and marginal category, holding 56% of land area and it is noticed further that 67% of farmers hold one hectare or less accounting for only 27% of the operated area. Moreover, these small holdings are fragmented into smaller parcels which is a major constraint for increasing productivity. A similar situation also prevails in Orissa.

Closely associated with the holding size and the resource base is the question of tenancy which is more widespread in the region. In Puri and Mayur bhanj districts of Orissa, one-third of cultivated area is under tenancy. West Bengal has 20 lakh share-croppers operating 25% of the total land area; only 12.3 lakh of whom are registered.

The Eastern Region accounts for larger percentage of poor people as compared to its share in population both in rural and urban area. This region accounted for around 33% of the poor though only 28% of the people of the country live in Eastern Region. In the rural areas, the Eastern Region, thus accounted for 35.4% of the rural poor, though Eastern Region has only 30.8% of the country's rural population. Similarly in urban areas, Eastern region accounted for 20.5% of the country's urban poor as compared its share of 19.2% urban people.

It is against this background that the Planning Commission appointed a Study Group for Agricultural Strategies in Eastern Region of India under the Chairmanship of Dr. S.P. Gupta, Adviser, Perspective Planning Division.

The composition of the Study Group is as under :—

1. Dr. S.P. Gupta, Adviser, Perspective Planning Division .. .. .. Chairman
2. Dr. G.R. Saini, E S A, Directorate of Economics and Statistics, M/o Agriculture, New Delhi .. .. .. Member
3. Dr. Prem Narain, Director IASRI New Delhi .. .. .. Member
4. Dr. Gunwant M. Desai, Indian Institute of Management, Ahmedabad, Gujarat .. .. .. Member
5. Dr. C. Mishra, Addl. Secretary, Planning, Govt. of Orissa, Bhubaneshwar .. .. Member
6. Dr. B.N. Tyagi, Director, Agr. Statistics Dte. of Agrieulture, Government of U.P. Lucknow .. .. .. Member
7. Dr. Chhatrasal Singh, Direetor, Fertiliser M/o Agriculture, Krishi Bhavan, New Delhi .. .. Member
8. Dr. P. Rangaswamy, Agro-Economic Research Centre, Delhi University .. .. Member
9. Dr. J.P. Singh, Agro-Economic Research Centre, Delhi University .. .. Member
10. Dr. (Miss) Kusum Chopra, Jawaharlal Nehru University Delhi .. .. Member
11. Dr. K. Subba Rao, Institute of Economic Growth, Delhi .. .. .. Member
12. Dr. S.K. Mitra, OSD, Dte. of Economies and Statisties M/o Agriculture, New Delhi .. .. Member
13. Dr. P.S. Sharma, Joint Adviser Planning Commission .. .. .. Member
14. Dr. Kanehan Chopra, Institute of Economic Growth, New Delhi .. .. Member
15. Shri S.S. Ahluwalia, Deputy Adviser, Planning Commission, New Delhi .. .. Member
16. Dr. G.K. Chadha, Consultant, Planning Commission .. .. .. Member
17. Shri Daya Krishna, SRO, Planning Commission .. .. Member
18. Dr. V.K. Malhotra, SRO, Planning Commis sion .. .. Member
19. Shri R. P. Nagi, RO Planning Commission .. .. Member
20. Smt. Uma Kapila Lecturer, Miranda College New Delhi .. .. .. Member
21. Mrs. S. B. Sarin, RO Planning Commis sion .. .. Member
22. Representatives from Agrieulture Dvn. Plan.-Comm. Govt. of West Bengal .. Member
23. Dr. Padam Singh, Joint Adviser, Planning Commission .. .. Member-Secretary.

For the distriet level analysis of agricultural production, data were colleeted for three years of 1970's (viz., 1970-71, 1971-72 and 1972-73) and for two years of 1980's (viz., 1980-81 and 1981-82). In addition, data were made available by Indian Agrieultural Statistics Research Institute for estimation of potential in the region.

To familiarise with the problems of the region several tours were undertaken, the details of which are as under :—

State	Members of the Team	Date of visit
1. *Bihar*	Shri S.S. Ahluwalia, Dy, Adviser, Planning Commission Dr. G.R. Saini, Dte. of Economics & Statistics, Ministry of Agriculture & Shri R.P. Nagi, R.O. Planning Commission.	June 6 to 12, 1984
2. *Orissa*	Dr. P. Rangaswamy, Consultant Planning Commission. Shri J.P. Singh, Dy. Director, Agricultural Economics Research Centre, Delhi University & Shri R.L. Verma, Dy. Director, R.B.I., New Delhi. Shri Ajit Singh, R.O., Planning Commission.	April 12 to 19, 1984
3. *West Bengal*	Dr. S.P. Gupta, Adviser, Planning Commission. Shri S.S. Ahluwalia, Dy. Adviser, Planning Commission Shri K.L. Datta, S.R.O., Planning Commission, and Shri R. Natarajan, Senior Economic Investigator, Planning Commission.	April, 19 to 26, 1984
4. *East U.P.*	Shri S.S. Ahluwalia, Dy Adviser Planning Commission Dr. (Miss) Kusum Chopra, Consultant, Planning Commission. & Dr. Dargoa Singh, Ex-Director, IASRI	April 22 to 29, 1984

This report contains five chapters and a summary. Chapter II of the report deals with Agrieultural productivity in general in the Eastern Region, whereas the productivity of rice and wheat have been dealt with in Chapters III and IV. The potential in the region has been studied in Chapter V.

TABLE 1.1

Geographical and Gross cropped area in 1980-81

State	Geographical area in 1980-81 Sq. Km.	Gross cropped area in 1980-81 (ha)
(1)	(2)	(3)
Bihar	173,877 (34.5)	11,148,219 (31.2)
Orissa	155,707 (30.9)	8,746,000 (24.4)
Eastern U.P.	85,844 (17.0)	8,203,581 (23.3)
West Bengal	88,752 (17.6)	7,654,620 (21.4)
Eastern Region	504,180 (100.0%)	35,752,420 (100.0%)
India	3,287,263	173,324,000
Eastern Region as % of India	15.3	20.6

NOTE—Figures in brackets represent percent to total.

TABLE 1.2

Cropping Pattern in Eastern Region in 1980-81

Crops	Gross Cropped Area (ha)					
	Bihar	Orissa	Eastern U.P.	West Bengal	Eastern Region	All-India
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1. Rice	5,503,055 (49.4)	4,174,940 (47.7)	2,875,822 (35.1)	5,193,128 (67.8)	17,746,945 (49.7)	40,429,952 (23.3)
2. Wheat	1,699,322 (15.2)	66,573 (0.7)	2,589,549 (31.5)	248,518 (3.3)	4,603,962 (12.9)	22,211,600 (12.8)
3. Other Cereals	1,058,293 (9.5)	524,560 (6.0)	603,407 (7.3)	70,327 (0.9)	2,256,587 (6.3)	36,462,150 (21.1)
4. Five major oil seeds	202,012 (1.8)	594,592 (6.8)	129,498 (1.6)	325,359 (4.3)	1,251,461 (3.5)	16,177,900 (9.3)
5. Jute & Mesta	180,120 (1.6)	91,521 (1.1)	3,353 (0.1)	594,527 (7.8)	869,521 (2.4)	1,224,600 (0.7)
6. Sugar cane	112,615 (1.0)	49,324 (0.6)	294,409 (3.6)	18,814 (0.2)	475,162 (1.3)	2,929,950 (1.7)
7. Others	2,392,802 (21.5)	3,244,490 (37.1)	1,707,543 (20.8)	1,203,947 (15.7)	8,548,782 (23.9)	53,887,848 (31.1)
8. Total Cropped Area (Gross)	11,148,219 (100.0)	8,746,000 (100.0)	8,203,581 (100.0)	7,654,620 (100.0)	35,752,420 (100.0)	173,324,000 (100.0)

NOTE:—Figures in brackets are percentages

TABLE 1.3

States' Share in the production of total cereals

State	Total Cereals (Tonnes)	
	1970-73 (Average)	1980-82 (Average)
Bihar	7,129,814 (32.4)	8,134,914 (30.4)
Orissa	4,233,815 (19.2)	4,657,314 (17.4)
Eastern U.P.	3,706,742 (16.8)	6,841,491 (25.5)
W. Bengal	6,936,950 (31.6)	7,148,246 (26.7)
Eastern Region	22,007,321 (100.0%)	26,781,965 (100.0%)
India	88,949,008	116,625,612
Eastern Region as % of India	24.7	23.0

NOTE—Figures in brackets represent percentage to total.

TABLE 1.4

Growth of Fertiliser Consumption, Percentage Gross Irrigated Area Production and Yield, 1970's *and* 1980's

	Per ha fertiliser Consumption in Kgs.		Percentage of Gross Irrigated area to Gross Cropped Area		Growth rates per annum 1970—1980					
					Total Fertiliser consumption	Gross Irrigated area	Production		Yield	
	1970's	1980's	1970's	1980's			Rice	Wheat	Rice	Wheat
Bihar	3.30	18.35	25.98	32.58	7.34	3.03	1.09	1.98	0.3	(—)0.5
Orissa	2.17	8.73	17.16	19.57	5.80	4.03	0.25	11.09	1.2	1.4
Eastern UP	7.19	48.87	32.28	40.36	9.79	3.14	4.65	10.16	2.9	3.5
West Bengal	3.55	36.92	14.66	20.54	14.74	4.32	0.86	(—)5.84	0.5	(—) 1.4
Eastern Region	4.04	26.98	23.07	28.60	9.98	3.42	1.25	4.88	0.8	0.9
All India	5.19	31.82	23.46	28.61	8.41	2.68	2.69	3.89	1.8	2.2

CHAPTER II

AGRICULTURAL PRODUCTIVITY IN THE EASTERN REGION

2.1. Introduction

This chapter presents the classification of districts of the various states of the Eastern Region according to their productivity levels. The time periods considered are 3 years of 70's (1970-73) and 2 years of 80's (1980-82). The productivity is measured in value terms per unit of net sown area. The value of output for each district has been arrived at by multiplying the output of each of the crops in 70's and 80's by the respeetive constant price prevailing in 1967-68. A total of 18 crops were selected to be covered by this study. Since the share of the total cropped area covered by these crops was different in each district, the value of the total output was inflated to represent 100 per eent of the cropped area in order to put the districts on the same footing. The value of output arrived at, was then divided by the net sown area of each of the districts to give productivity figures. The districts were then classified into very low, low, medium, high and very high productivity categories using the following criteria :

Category	Productivity level
Very low productivity	Rs. 950 or less
Low productivity	Rs. 950—1150
Medium	Rs. 1150—1650
High	Rs. 1650—2000
Very high	More than Rs. 2000

2.2. Share of area and output by States :

Table 2.1 presents the share of area and value of output of different States in the eastern region. Bihar State which accounts for nearly one-third of the total cultivated area, recorded a decline in the share of value of agricultural output from 31 per cent in the 70's (1970—73) to 27 per cent in the 80's (1980—82).

All the other states of the eastern region viz. West Bengal, Orissa and East Uttar Pradesh shared cultivated area equally but because of relatively higher per hectare productivity in West Bengal, the contribution of this state to output was nearly 29 per cent in 70's which declined to 27 per cent in the following decade. The share of Orissa and Eastern Uttar Pradesh in the region's output has increased over time. It can be seen from table 2.1, that the annual growth rates of productivity, are as low as 0.5 per cent and 1.2 per cent in Bihar and West Bengal but are relatively higher at 2.6 and 3.5 per cents in Orissa and Eastern U.P. respectively. For the Eastern Region as a whole, the growth rate of productivity is also only 1.8 per cent which is lower than 2.2 per cent for the country as a whole. The prime reason being that the states of Bihar and West Bengal which together contribute nearly 55 per cent to the net sown area as well as production of the region, have performed poorly in terms of growth of productivity.

2.3. Changes in agricultural productivity

Table 2.2 presents the movement of the 60 districts of the eastern region on the basis of changes in aggregate agricultural productivity defined as value of output per hectare of net sown area in summary form in a transition matrix. At the beginning of 1970's 26 (out of 60) districts were in the low productivity range (9 Bihar+ 7 East U.P.+1 West Bengal). Of these 26 low productivity districts 15 moved into medium productivity range by 1980's but still remained in the low productivity range. Of these 11, 7 belonged to Bihar, 3 to Orissa, and one to east U.P. It is significant to note that by 1980 practically all but one district of eastern U.P. were either in medium or high productivity range.

At the beginning of 1970s, 25 districts were in medium productivity category (6 Bihar+4 Orissa+8 East U.P.+ 7 West Bengal). Of these, 14 moved into high productivity range, but 11 did not record any upward mobility. Of the 11 not recording any change, 5 belonged to Bihar, 4 to West Bengal, 1 each to east U.P. and Orissa.

In 1970, the eastern region had only 9 high productivity districts. While 8 remained in this category, 1 had slipped into medium productivity category by 1980. However, since other medium productivity districts of 1970s recorded upward mobility, the total number of districts in high productivity category rose to 22 by 1980.

Table 2.3 presents the classification of districts according to their productivity levels together with share of area and output from different productivity regions in 70's and 80's. The three States of Bihar, Orissa and eastern U.P. have indicated a significant decline over time in the share of output which is contributed by districts in the very low and low productivity sub regions. The cultivated area of Bihar in the two low productivity categories, for example, has declined by almost one-third in 1980's. For Orissa it has declined by a little more than 50 per cent, while the decline for eastern U.P. is very marked where the area share has fallen from nearly 46 per cent in 1970's to as low a figures of 8 per cent in 1980's. The basic reason for the change in the share is the reduction in the number of districts of each state falling in these categories. No districts of Orissa and of eastern U.P., remains in the 'very low productivity' category in 1980's. However, the area share of Orissa in the 'low productivity' subgroup increased over time due to the shifting up of some districts from the 'very low productivity' category.

TABLE 2.1

Cultivated Area, Value of output and productivity levels in the States of the Eastern Region

State/Region	1970—73					1980—82					Growth Rates		
	Net sown area (NSA) 000' hect	Share of NSA in eastern region	Value of output (Rs. million)	Share of value of output in eastern region	Productivity per NSA	Net sown area'000 hects.	Share of NSA in eastern region	Value of output (Rs. million)	Share of value of output in Eastern region	Productivity per NSA	Area	Output	Productivity
Bihar . .	8,261.31	32.91	10,345.62	30.97	1,252.30	8,314.83	32.40	10,951.58	27.09	1,317.11	0.07	0.60	0.53
Orissa .	5,663.00	22.56	6,539.01	19.84	1,154.69	6,130.00	28.89	9,032.90	22.34	1,473.56	0.84	3.46	2.60
Eastern U.P.	5,742.19	22.87	6,840.73	20.48	1,191.31	5,649.76	22.02	9,350.89	23.13	1,655.10	0.18	3.34	3.52
West Bengal	5,436.93	21.66	9,684.76	28.98	1,781.29	5,565.00	21.69	11,098.84	27.45	1,994.40	0.25	1.44	1.20
Eastern Region .	25,103.43	100.00	33,410.12	100.00 (27.69)	1,330.90	25,659.58	100.00 (18.29)	40,434.21	100.00 (27.24)	1,575.79	0.23	2.03	1.79
All India .	139,534.00		120,666.60		864.78	140,270.00		148,464.59		1,058.42	0.60	2.21	2.15

NOTE—Figures in parenthesis indicate the share of the Eastern Region in India.

TABLE 2.2

Transition matrix showing the mobility in Productivity per hectare of the districts in Eastern Region

	Initial situation (1970)	1980		
		Low Productivity Range	Medium Productivity Range	High Productivity Range
Low Productivity Range	(26) 108, 112, 116, 119, 121, 122, 124, 126, 128, 201, 202, 204, 206, 207, 208, 209, 210, 213, 301, 304, 308, 309, 312, 313, 314, 411.	(11) 0.42* 108, 112, 119, 122, 124, 126, 128, 207 208, 213, 304,	(15) 0.58* 116, 121, 201, 202, 204, 206, 209, 218, 301, 308, 309, 312, 313, 314 411	(0)
Medium Productivity Range	(25) 103, 104, 106, 107, 109, 115, 203, 205, 211, 212, 302, 303, 305, 306, 307, 310, 315, 311, 401, 406, 407, 410, 413, 414, 415.	(0)	(11) 0.44* 103, 106, 107, 109, 115, 212, 305, 406, 410, 413, 415	(14) 0.56* 104, 203, 205, 211, 302, 303, 306, 307, 310, 311, 315, 407, 414.
High Productivity Range	(9) 120, 127, 402, 403, 404, 408, 409, 412, 405.	(0)	(1) 0.11* 127,	(8) 0.89* 120, 402, 403, 404, 405, 408, 409, 412

NOTES—Figures in brackets are number of districts.

Figure with * is the probability of transition.

TABLE 2.2(*a*)

Codes and names of the districts

Bihar		Orissa		Eastern U.P.		West Bengal	
Code	Name of district	Code	Name of district	Code	Name of district	Code	Name of district
103	Bhagalpur	201	Balasore	301	Allahabad	401	24 Parganas
106	Champaran	202	Bolangir	302	Azamgarh	402	Nadia
107	Dharbanga	203	Cuttack	303	Ballia	403	Murshidabad
108	Dhanbad	204	Dhankunal	304	Bahraich	404	Bardwan
109	Gaya	205	Ganjam	305	Basti	405	Birbhum
112	Hazari Bagh	206	Kalahandi	306	Deoria	406	Bankura
115	Monghyr	207	Keonjhar	307	Faizabad	407	Midnapore
116	Muzaffarpur	208	Koraput	308	Ghazipur	408	Hoogli
119	Palamau	209	Mayurbhanj	309	Gonda	409	Howrah
120	Patna	210	Phulbani	310	Gorakhpur	410	Jalpaiguri
121	Purnea	211	Puri	311	Jaunpur	411	Darjeeling
122	Ranchi	212	Sambalpur	312	Mirzapur	412	Malda
124	Saharsa	213	Sundargarh	313	Pratapgarh	413	West Dinajpur
126	S. Parganas			314	Sultanpur	414	Cooch Behar
127	Saran			315	Varanasi	415	Purulia
104	Shahabad						
128	Singhbhum						

TABLE 2.3

Classificotion of districts of the vorious stotes of the Eastern Region occording to their productivity levels in terms of the net sown area

Level of Productivity N.S.A.	1970-73 Number/Name of the districts in States: No.	Name	N.S.A. under given districts (Hectares)	Share in States & total in E. Region	Inflated value of output in Rs. Million	Share in States of Total in E. Region.	Productivity/ N.S.A.	1980-82 Number/Name of districts in States: No.	Name	N.S.A. under given districts (Hectares)	Share in tate of total in E. Region	Inflated value of output (Rs. Million)	Share in state of total in E. Region.	Productivity/ N.S.A.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Bihor							*Bihar*					
Very low O—Rs. 950	B—4	Hazaribagh Palamau Ranchi Singhbhum	B . 1757562	21.27	1,487.74	14.38	846.48	B—3	Palamau, Ranchi. Singhbhum	B : 1338000	16.09	1,176.54	10.74	879.33
		Orissa :												
	0—7	Balasore Kalahandi Keonjar Koraput Sundergarh Phubani Mayurbhanj	O : 2649335	46.78	2,420.11	37.01	913.48							
		Eastern U.P.												
	EUP—2	Bahraich Mirzapur	EUP : 8414738	14.19	704.28	10.30	864.42							
	(—13)	Sub-Total	5221635	20.80	4.612.13	13.81	883.27	(3)	Sub-Total (V. low)	1338000	5.21	1,176.54	2.91	879.33
		Bihor							*Bihor* :					
Low Rs. 950-1150	B—5	Dhanbad Muzaffarpur Purnea Saharsa Santhal Parganas	B . 2198692	26.61	2,405.97	23.26	1,094.27	B—4	Dhanbad, Hazaribagh Saharsa Santhal Parganas	B : 1390000	16.72	1,466.51	13.39	1,055 .04
		Orissa :							*Orissa* :					
	0—2	Dhenkanal Bolangir	O : 793000	14.00	879.58	13.45	1,136.43	0—3	Keonjhar, Koraput Sundergarh	O . 1423000	23.21	1,555.11	17.22	1,092.84
		E.U.P. .							*E.U.P.* :					
	EUP—5	Gazipur Partapgarh Gonda Allahabad Sultanpur	EUP : 1836791	31.99	1,969.48	28.79	1,072.24	EUP—1	Bahraich	EUP : 455623	8.06	451.80	4.83	991.61
		West Bengo' :												
	WB—1	Darjeelin.	WB : 102932	1.89	114.31	1.18	1,110 53							
	(13)	Sub-Total	4931416	19.65	5,369.44	16.07	1,088.82	(8)	Sub-Total (low)	3268703	12.74	3,473.42	8.59	1,062.63
	(26)	Total (V. low+low)	10153051	40.45	9.981.57	29.88	983.11	(11)	Total (V. low+low)	4606703	17.95	4649.96	11.50	1,009.39
		Bihor :							*Bihor* :					
Medium B—6 Rs. 1150-1650		Bhagalpur Champaran Shahabad Dharbhanga Monghyr Gaya.	3409522	41.28	4 837.52	46.76	1,415.11	B—8	Bhagalpur. Champaran, Darbhanga, Gaya. Monghyr. Muzaffarpur, Purnea, Saran.	4448826	53.50	6,208.58	56.69	1,395.55

TABLE 2.3—*Contd.*

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Orissa :							*Orissa* :					
	O—4	Cuttack Puri Sambalpur Ganjam	2220667	39.21	3,239.22	49.54	1,458.67	O—7	Balasore, Bolangir, Dhenkanal, Kalahandi, Mayurbhanj, Phulbani, Sambalpur.	3033009	49.48	4,140.28	45.84	1,365.08
		E.U.P.							*E.U.P.* :					
	EUP—8	Azamagarh Ballia, Basti, Deoria, Faizabad Gorakhpur Jaunpur Varanasi	3090656	53.82	4,166.97	60.91	1,348.25	EUP—7	Allahabad, Gonda, Basti, Gazipur, Mirzapur, Pratapgarh, Sultanpur	2690234	47.62	3,979.46	42.56	1,479.22
		W. B. :							*W. B.* :					
	WB—7	24-Parganas Bankura, Midnapur, Jalpaiguri, W. Dinajpur, Cooch-Bihar, Purulia.	3806800	60.82	5,052.14	52.17	1,528.50	WB—5	Bankura, Jalpaiguri, W. Dinajpur, Purulia, Darjeeling.	1569960	28.21	2,327.09	20.97	1482.26
(25)	Total		120274645	47.91	17,295.85	51.77	1,438.01	(27)	Total	11742020	45.76	16,655.41	41.19	1,418.45
		Bihar							*Bihar* :					
High— Rs. 1650—2000	B—2	Patna, Saran	895533	10.84	1,614.39	15.60	1,802.71	B—2	Shahabad Patna.	1138000	13.69	2,099.95	19.17	1,845.3
									Orissa :					
								O—2	Ganjam Puri.	977000	15.94	1,804.89	19.98	1,847.38
		W. Bengal :							*E. U. P.* :					
	WB—1	Malda	258633	4.76	447.07	4.62	1,728.59	EUP—4	Azamgarh, Ballia, Gorakhpur, Varanasi.	1466296	25.95	2,752.69	29.44	1,877.31
									W. B. :					
								WB—4	24 Paraganas Midnapur, Cooch-Bihar Malda.	2103770	37.80	3,794.85	34.19	1.803.88
(9)		Sub-Total	11541664	4.60	2,061.46	6.17	1,786.10	(12)		568,5016	22.16	10,452.38	25.85	1,838 58
									Orissa :					
Very High Rs. 2000 & above								O—1	Cuttack	697,000	11.37	15,32.62	19.98	2,198.88
							F. U. P. :							
								EUP—3	Deoria, Faizabad, Jaunpur.	10,37,602	18.37	2,166.94	23.16	2,088.41
									W. B. :					
	WB—6	West Bengal Nadia, Murshidabad Burdwan, Birbhum Hooghly, Howrah	1768568	32.58	4,071.42	42.03	2,302.00	WB—6	Nadia, Murshidabad Burdwan, Birbhum, Hooghly, Howrah.	1,891,240	33.98	4,976.90	44.84	26,31.55
(6)		Sub-Total	1768568	7.04	4.071.24	12.19	2.302.00	(10)	Total	3625842	14.13	8,676.46	21.46	2,392.95
(9)		Total (high+V high)	2922734	11.64	6.132.70	18.36	2,098.28	(22)	Total (High +V. High)	9310858	36.29	10,128.84	47.31	2,054 67
(60)		GRAND TOTAL (Eastern Region)	25103430	100.00	33,410.12	1,000.00	1,330.90	(60)	GRAND TOTAL (Eastern Region)	2,56,595.81	100.00	40,134.21	100.00	1,5575.79

The share of areas falling in the medium productivity category has increased for Bihar and Orissa, but since relatively larger sized districts of eastern U.P. and of West Bengal have moved on to the higher productivity category, the share of areas of these two states in this group has declined. In the 'high productivity group' the area share of West Bengal has increased phenomenally. Bihar and Orissa also have relatively larger area in high productivity group in the 80's. In the last category termed as 'very high', districts of Orissa and eastern U.P. are completely new entrants, but no qualitative change in the districts of West Bengal are noticed in terms of the area share though average productivity level for the identified districts has gone up from Rs. 2302 in the 70's to Rs. 2632 in the 80's.

In most of the States (except West Bengal), the average productivity per net sown area of district falling in the 'low' category shows a decline in 1980's compared to 1970's. This is primarily because of the mix of districts. For example, districts like Muzaffarpur, Purnea which were among more progressive districts, a shift out from the 'low' category in 1980's was seen. Similarly, among Orissa districts Dhenkanal and Phulbani both indicating larger strides in productivity levels, shifted up to Medium Productivity levels in 1980's. Uttar Pradesh was represented by a sole district Bahraich in the 80's while districts like Ghazipur, Pratapgarh, Gonda and Sultanpur had high growth rates of per hectare productivity and therefore could get included in medium productivity range.

Similarly explanations can be found for districts falling in 'medium' productivity classification from where the relatively progressive districts have shifted up to the higher range. Again in this group, while the average productivity of Orissa and east U.P. districts has shown an increase, that of Bihar and West Bengal had declined over time. In the 'high' and 'very high' productivity classification, average productivity of districts of all states shows an increase over 1970's indicating that the districts which have shifted up in 1980's had a higher rating in terms of productivity levels when compared to the ones which were included in these categories in 1970's.

2.4. Growth rate of productivity

Superimposing growth rates of productivity of the various districts, a clearer picture for the various states emerges. The districts in Table 2.4 have been allotted according to the productivity levels of 1980's and the compound growth rates. One notes it with great concern that a large number of districts of Bihar are either negatively growing or are growing at very low positive rates. Only 4 districts of this state fall under medium growth rates. Except for two districts Patna and Saran, all the other districts of Bihar were of either low or medium produtivity only. Two-thirds of the districts of West Bengal also are either low growing or are negatively growing though they fall either under

TABLE 2.4

Allotment of districts according to productivity levels of 1980's and compound annual growth rates of productivity

	Negative growth rate	Low growth rate 0—1.5	Medium growth rate 1.5—3.0	High growth rates >3.0
Low productivity (upto Rs. 1150 per hectare)	B—Dhanbad Singhbhum	B—Ranchi, Saharsa Santhal Parganas Hazaribagh	B—Palammu, Muzaffarpur Purnea	B—Bhagalpur, Phulbani Mayurbhanj
		O—Keonjhar	O—Koraput, Sundargarh Dhankanal, Bolangir Kalahandi	EUP—Sultanpur, Ghazipur, Gonda, Pratapgrah.
			EUP—Allahabad, Bahraich Mirzapur	
Medium productivity (Rs. 1150—Rs. 1650 Per hectare)	B—Bhagalpur WB—Jalpaiguri West Dinajpur	B—Darbhanga, Gaya, Manghyr, Shahabad O—Puri EUP—Basti WB—Midnapur, Bankura Purulia	B—Champaran O—Samhalpur, Ganjam EUP—Ballia WB-24 Parganas Cooch Behar, Darjeeling	O—Cuttack EUP—Deoria, Faizabad, Jaunpur, Gorakhpur, Varanasi, Azamgarh
High productivity (Rs. 1650 or more per hectare)	B—Saran, Patna	WB—Murshidabad, Birbhum, Howrah, Malda	WB—Nadia, Burdwan, Hooghly	
Total	7	18	21	14

B=Bihar, O=Orissa, EUP=East U.P. and WB=West Bengal

medium or high productivity sub-groups. Only one-third of total West Bengal districts have medium growth rates. Eleven out of thirteen districts of Orissa's and all but Basti district of eastern U.P. are either medium growing or high growing pushing up most of the low productivity districts of 1970's of these two states into medium productivity in 1980's and the medium productive ones of 1970's into high productivity districts in 1980's.

TABLE 2.5

Share of net sown area of 1970's falling under various levels of growth rates

State	Negative growth rates	Low growth rates	Medium growth rates	High growth rates
Bihar . . .	20.34	53.45	26.21	..
Orissa . .	6.90	5.57	57.04	30.49
East U.P. . .	14.85	9.76	26.64	63.60
West Bengal .	14.85	48.12	37.03	..
Eastern region .	11.47	31.50	35.60	21.43

The above table shows that nearly three-quarter of cultivated area of Bihar state and two-thirds of West Bengal state has been operating under conditions of negative and very low growth rates, while 87 per cent of Orissa's and more than 90 per cent of eastern U.P.'s cultivated area is being operatived under medium and high growth rates resulting in an upward movement in the ladder of productivity in these states where only a few districts in 1980's operated under conditions of 'low productivity'. With passage of time, districts with a substantial percentage of net sown area of eastern U.P. and of Orissa have moved from low to medium and from medium to high productivity levels, while in case of Bihar nearly 70 per cent of the districts have in 1980's remained in the same classification group as that of 1970's and a little more than one-third of total districts continue to operate under low productive conditions. West Bengal, though covered largely under medium and high productivity levels, has substantial number of districts which have indicated no change in their classification under respective productivity categories. In fact, one district (Saran) in Bihar has been pushed downwards from high to medium productivity level with passage of time.

The net result is that for the eastern region as a whole, while 43 per cent of the cultivated area is covered by either very low and negative growth rates of per hectare productivity, only a little more than half of the cultivated area is operated under medium and high growth rates. A large part of the eastern region thus continues to be characterised by agricultural stagnation.

Many of the identified low and negative growing districts of the eastern region happen to be upland or hill districts where the level of irrigation happens to be very low. But what is more intriguing and more disheartening is the poor growth performance of the districts of Bihar particularly of the Ganga plains including Gaya, Patna, Monghyr, Shahabad, Bhagalpur, Saran and coastal districts like Puri and Ganjam of Orissa where not only the level of net irrigated area is high but has increased substantially during the past decade. As opposed to this, some less endowed districts like Palamau, Muzaffarpur, Purnea of Bihar and the upland districts of Orissa have performed rather well in terms of change during the period of the study. The high growth districts of eastern U.P. clearly have high and increasing levels of net irrigated area. Therefore, it becomes necessary at this stage to have an indepth analysis of the causes leading to a stagnation or to a growth in productivity levels of the various identified districts of this region.

2.5. Disparity in productivity level

With change in productivity levels, the disparity among districts in the eastern region seems to have remained the same over time when the co-efficient of variation of productivity marginally increased to 32.77 in the 1980's compared with 32.56 in 1970's.

This is due to the fact that three states Orissa, East U.P. and West Bengal indicate an increase in the district level disparity measured in terms of co-efficient of variation in 1980's compared to 1970's while Bihar indicates a lowering down of inter-district disparities. Similarly, among the classified regions, inter-district disparities have increased only in the high productive region. No change is noticeable in the medium productivity region.

2.6. Determinants of Productvity

It is common knowledge that water management (irrigation, flood control and prevention of water logging) is the key to the agricultural transformation of the eastern region. Therefore, the most likely variable explaining the differential performance of the districts is the change in irrigation ratio.

TABLE 2.6

Irrigation status in Eastern Region

	Net cropped area irrigated as %of NSA		Source-wise irrigation (1980-81)		
	1970—73	1980-81	canals	TWs	others
Eastern U.P. .	40.47	52.74	26.70	59.09	14.21
Bihar . . .	28.03	35.47	37.07	26.82	36.11
West Bengal .	15.28	22.00	50.26	20.95	28.79
Orissa . . .	15.23	19.84	63.10	2.11	34.79

Clearly, both in terms of quantity and quality of irrigation eastern Uttar Pradesh has done far better than others in the region. However, in terms of irrigation ratio, Bihar also appears to have done reasonably well. Orissa though lagging behind has displayed much greater dynamism than Bihar in terms of upward mobility of value of output per hectare.

Changes in irrigation ratio, clearly, are a partial explanation for the observed variation in the productivity performance.

It is important to examine whether, apart from irrigation infrastructure, other supporting physical infrastructural services and institutional infrastructure played an important role in triggering off the growth process in *some* districts of the eastern region, especially in eastern Uttar Pradesh. These supporting services include development of rural roads, fertiliser distribution outlets, agricultural market yards, storage for fertiliser and output, credit institutions, etc. Because of data limitations, we considered three supporting services, viz., rural roads, fertilizer retail outlets, and credit institutions, apart from conventional variables.

The importance of irrigation status in influencing the changes in agricultural productivity is well recognised. A higher irrigation ratio may be expected to induce farmers to increase fertilizer application. This, of course, depends on (*a*) farmer's capacity to buy fertilizers which in turn depends on his *access* to credit institutions; and (*b*) availability of fertilizer which in turn depends on *physical access* to a fertilizer retail outlet. Wherever a change in irrigation status did not result in pushing up fertilizer use and farm productivity, it is necessary to examine whether the access to credit and/or physical access to fertilizer is inadequate in that district/region.

Irrigation, of course, is a necessary condition to increased fertilizer application only under favourable agro-climatic conditions of which irrigation ratio is a dominant part. However, a rise in irrigation status alone cannot step up productivity levels to the same degree as 'irrigation with fertilizers'. Given these considertions one should expect fertilizer consumption per hectare to emerge as the dominant explanatory variable for the observed variation in the productivity levels across the districts.

Step-wise regression analysis (results given in the appendix-1) corroborate the aforesaid observations. When one considers all the 60 districts of the eastern region, fertilizer use per hectare emerges as a dominant variable explaining the observed inter-district variation in the productivity levels for 1980s.

We then considered the role of fertilizer on agricultural productivity separately for the low productivity (LP), medium productivity (MP) and high productivity (HP) districts.

Again, the dominant variable explaining inter-district variation in productivity *within* each category turns out to be fertilizer consumption per hectare.

Since fertilizer consumption per hectare played such a crucial role in determining productivity, we in turn examined the determinants of fertilizer offtake. We considered the role of irrigation, physical access to fertilizer (fertilizer retail outlet), and credit institutions.

As between the three categories of districts, there are interesting differences with respect to determinants of fertilizer consumption. In the LP districts, fertilizer offtake appears to be essentially demand-determined, being explainable almost entirely (and directly) by the quantity and quality of irrigation and soil rating index. It must be stressed that in these disticts, the average *level* of fertilizer use is very low, essentially because the demand for fertilizer is very low.

In the medium productive districts also the fertilizer consumption is influenced by quantity and quality of irrigation. In the high productivity districts, fertilizer consumption appears to be influenced *primarily* by the, supply-side factors, viz., *access* to fertilizer retail outlet credit institutions, rural road network, etc.

These result would suggest that, in region with extremely poor irrigation ratios, the need for raising this ratio through public investments in creation of irrigation facilities and efficient water management is overriding. But in regions where irrigation ratio has improved, attention should be focussed on strengthening of credit institutions and infrastructure which in turn influence productivity through increased efficiency of the input delivery system.

While not denying the critical role played by water management in the agricultural transformation of the eastern region, we have shown the importance of the *level* of physical and institutional infrastructural development in indirectly influencing agricultural productivity via determining the access to input and credit markets. There appears to be an urgent need for proper *sequencing* of public investment decisions in various activities in different districts. Thus in districts with extremely low irrigation ratio, the need is clearly for raising this ratio via public investment, so that an adequate *demand* for fertilizer is generated. In regions where irrigation ratio has improved, public investment decisions must focus not only on further improving this ratio, but also simultaneously on improving infrastructural services, so that the *supply* bottlenecks for modern *inputs* are eased. In the few districts which attained very high productivity levels (and irrigation ratios), public efforts would have to be directed towards *output* marketing facilities, market yards and public price support operations wherever necessary.

Clearly, each set of districts would require a different sequencing of public investment.

The relationship between infrastructure and agricultural productivity has other implications. First, it suggests that the benefits obtainable from public investment in irrigation, extension and agricultural research may be limited if the complementary infrastructure investment are not made, as is evident from the experience of some of the lagging districts of Bihar. Second, the productivity effect of investment in rural roads and other types of infrastructure not directly related to the agricultural production process constitutes a potentially important *external* benefit of these investment. To correctly evaluate the pay-offs to infrastructural investments, planners should include these external benefits in project evaluations of such investments.

2.7. Conclusions

The classification of districts of Eastern Region by productivity level revealed that 26 out of 60 districts were in the low productivity range in 1970's of which 9 each were from Bihar and Orissa, 7 from East U.P.

and 1 from West Bengal. Of these 26 low productivity districts, 15 moved into medium productivity range by 1980's. Of 11 not moving upwards, 7 belonged to Bihar, 3 to Orissa, and one to East U.P. Further, 25 districts in 1970's were in medium productivity category of which 6 belonged to Bihar, 4 Orissa, 8 east U.P. and 7 West Bengal. Of these 25, 14 moved into high productivity range. Of the 11 not recording any change, 5 belonged to Bihar, 4 to West Bengal, 1 to east U.P. and 1 to Orissa. In 1970's the eastern region had only 9 high productivity districts. While 8 remained in this category in 1980's, 1 came down to medium productivity category. Since other medium productivity districts of 1970's recorded upward mobility, the total number of districts in high productivity category rose to 22 by 1980.

Further, the classification of districts by growth rates of agricultural productivity showed that more than 90% cultivated area in Eastern U.P. and about three-fourth in Orissa is operating under medium and high growth rates while nearly three-fourth in Bihar and two-thirds in West Bengal is operating under negative or very low growth rates. For the eastern zone as a whole nearly 40% of the cultivated area is operating under negative or very low growth rate.

As to the determinants of productivity the most important variable explaining inter-district variation in productivity within each category turns out to be fertilizer consumption per hectare, which in turn is determined by the quantity and quality of irrigation, access to inputs and the availability of infrastructure. As between the three categories of districts, there are differences with respect to determinent of fertilizer consumption. In the low productive districts, fertilizer consumption appears to be demand-determined, being explainable by the quantity and quality of irrigation and soil rating index. In the medium productive districts also the fertilizer consumption is influenced by quantity and quality of irrigation. In the high productivity districts fertilizer consumption is influenced primarily by the supply-side factors, viz. access to fertilizer retail outlet, credit institutions, rural road network etc.

CHAPTER III

PRODUCTIVITY OF RICE IN THE EASTERN REGION

3.1. Region

The average yield of rice during 1980—82 for the Eastern Region was (1034 kg/ha) which is around 3 quintals less than the all India average. Of the four east Indian States, West Bengal has the highest average yield of rice (1280 kg/ha) which is only 42 kg/ha less than the national average. The yields of the other three states are just between 9 and 10 quintals/ha.

The district-wise yields show that all but one district in Bihar are in the low and medium yield ranges (4 to 12 quintals/ha), while in Orissa and east U.P., most of the districts are in the medium range (8 to 12 quintals/ha). In the case of West Bengal, the districts are distributed in the medium and high yield groups.

The growth rates in rice-yields (between 70's and 80's) have also been not satisfactory in the region except for east U.P. which has achieved a growth rate of 2.9%. In Bihar as well as West Bengal the average growth rate was very low (less than 0.5%) indicating a stagnancy of yields—at a low level in Bihar and at a relatively high level in West Bengal. Orissa had a slightly higher growth rate (1%). The average growth rate for the eastern region is just 0.8% compared to 1.8% for all India.

About 60% of the districts in Bihar and 40% in West Bengal had negative growth rates. About one-third of the districts in the eastern region had experienced decrease in yields. However, nearly one-third of the districts of the eastern region (mostly in east U.P.) had growth rates above the national average (1.8%).

Superimposing the growth rate categories on the yield groups, we see that most of the districts are in the high yield-low growth categories in West Bengal, in the medium yield—high growth categories in east U.P., in the medium yield—medium growth categories in Orissa and in the low to medium yield—low growth groups in Bihar.

One major reason for the low yield levels of eastern region States compared to the rest of India, particularly the chief rice-growing Southern States viz., Andhra Pradesh and Tamil Nadu is the much lower level of irrigation in the former. About three-fourths of the rice area in the Eastern Region is still cultivated under the uncertain monsoon conditions attended by floods as well as droughts. The per cent of rice area irrigated ranges from as low as 11% in East U.P. to around 34% in Bihar.

The inter-state differences in yields within the Eastern Region are not, however, explained by irrigation alone. For instance, in spite of Bihar being better placed in respect of irrigation, the yields level is low, whereas that of West Bengal is much higher, though its irrigation ratio is lower. This means that the irrigation management is as much important as the creation of irrigation potential.

As several studies and our own field investigations have shown, flooding and drainage problems are quite serious in the eastern region which block an optimal utilisation of the available irrigation potential. There are also other problems like saline and alkaline soils found over large areas.

Productivity of rice depends not only on irrigation facility but also on other yield raising inputs like HYV seeds and fertilisers. Here again we find that the eastern region is lagging behind the rest of India. HYVs have covered only 31% of the rice area in the eastern region compared to 46% for all India. The HYV coverage is less than 31% in 3 States—Bihar, West Bengal and Orissa. It is high (50%) only in East U.P. The yields are, however, low there because of very little irrigation coverage.

Technological advancements with regard to rice have not been as spectular as in the case of wheat. Lack of suitable varieties for the flood prone low lands has been a major constraint to increase in productivity. Farmers do not consider fertiliser use to be quite profitable under flood prone or drought prone conditions. Eastern region is also deficient in infrastructural facilities like roads, availability of power, credit, sale outlets for seeds and fertiliser etc., which hamper the spread of even available technology. Lack of procurement agencies and absence of regulated markets are the other major disincentives for the farmers to adopt the costly inputs.

In order to get more meaningful insights into the factors affecting rice yields, we are presenting below a district-wise picture of rice yields and some of their major determinates mentioned above, on the basis of available data. This analysis has been done according to the ecological regions in each state incorporating also the field observations. The district level variables taken into account are the following :

(1) Average yield of rice (1980—82).

(2) Per cent of rice area irrigated (1980-81).

(3) Per cent of area under HYVs (1980-81).

(4) Growth rates of yields (1980—82 over 1970—73).

(5) Growth rates in irrigation area (1980—82 over 1970—73).

(6) Growth rates in HYVs area (1980—82 over 1970—73).

(7) Average size of operated holding (1976-77).

(8) Irrigation pumosets and tubewells energised per 10,000 ha (1981).

(9) Size of commercial Bank Credit per ha (1980).

The first six variables mentioned above are drawn from cross section data. We have analysed the relationship between them by ranking the districts in terms of each variable. The variables are ranked in descending order—from the highest to the lowest, except for the 'size of holding' which is ranked in ascending order so as to examine the hypothesis of its inverse relationship with yield. If the difference in the ranks of a district between variables is 3 or less, it is assumed that the two variables are positively associated. More the number of districts with such association, the higher is the association between the two variables.

3.1.1. *Bihar*

Bihar is usually divided into three ecological regions viz., North plains (north of Ganga), South plains and Chotanagpur plateau.

South Plains—The yields of rice are higher in the south plains compared to the other two regions (Table 3.3). At least in 3 out of 5 districts of this region, the yield is above 10 quintals/ha., though in the other two, it is less than the state average i.e., 9 quintals/ha. The higher yields are, in general associated with higher irrigation and HYV coverage. But in the district of Gaya, in spite of the entire area under the rice being irrigated, the HYV coverage and the yields levels are low and similarly the yield in Monghyr is not commensurate with input levels. It is possible that yields in these districts are depressed by the saline and alkaline soils found in them as well as the flood-prone conditions of the low lands.

Most of the canal irrigation in Bihar is concentrated in the south plains, but its effective utilisation is low mainly due to bad drainage and unregulated water supply. If an effective programme for the construction of field channels and drainage channel is implemented in the command areas, it will help in better utilisation of irrigation water and raising of rice yields in most of the districts. More attention should be paid in this region to better distribution devices including warabandi so as to ensure equity particularly for farmers in the tail-ends of the commands. Extension of tubewell irrigation, however, is likely to have a beneficial impact on water management in this area.

In spite of positive growth rates in inputs, rice yields, however, have either remained stagnant or declined in south plains, possibly due to poor water management and deteriorating soil conditions. Concerted steps taken to ameliorate these conditions will help in realising the potential of the soil and water resource. Such plains districts are known to be prone to both floods and droughts depending on the weather conditions. Flood control measures need to be intensified or revamped. Further, more research emphasis need to be laid on developing HYVs which are resistent or tolerent to floods/droughts.

North Plains—Yields are, in general, low in the north plains districts, with the exception of Champaran. This is partly due to the very low level of irrigation in 4 out of 6 districts and low coverage under HYV in 3 districts. Moreover, flooded conditions are, possibly, more common and acute in the north plains than in the south. This is a major factor adversely affecting the spread and impact of HYVs and fertiliser use, particularly in the low lands which produce a major part of the rice output. The uplands, on the other hand, are faced with the serious problems of soil erosion reducing its fertility. This also contributes to the silting and raising of river beds which in turn, increases the danger of floods in the low lands.

Soils are largely alkaline in this area. The problem is quite serious in districts like Saran and Saharsa where yields are very low. This calls for a massive programme of amelioration with gypsum and other chemicals. Improved drainage will also help in this regard.

In contrast to the south plains districts, rice yields have recorded positive growth rates in most of the districts in the north, in response to the growth in per cent of irrigated rice area and HYV area. This may be attributed mainly to the higher growth of tubewell irrigation in this area compared to the south. Growth rates in inputs have been, in general, higher in the north plains than in the other two regions.

Chotanagpur Plateau—Rice yields are also generally low in the plateau region where it is cultivated predominantly under rainfed conditions. Consequently, the percentage of area under HYV is also very low. HYVs of paddy suited to rainfed conditions seem to have made little headway in this area. In spite of such a low level of input, the yields are not lower than those of the north plains, though lower than those in the south plains. However, rice yields have either been stagnant or have declined in this region over the last decade, as a result of a fall in the per cent of irrigated area under rice. The sources of sparse irrigation in this area (mainly tanks, wells, streams) etc. seem to have fallen into disuse over time. There is little scope for canal irrigation here. Tubewell irrigation also has not spread due to rocky subsoil and high cost, though it may be quite feasible in several areas.

Because of the hilly terrain, denudation of forests and lack of crop or grass cover over large areas, the problem of soil erosion has assumed serious proportions. Soil acidity is another major problem here, as alkalinity is in the north plains. It reduces the fertiliser response which can, however, be restored through application of lime to the soils. Thus, the above problems call for the adoption of an integrated programme of soil amelioration, conservation, ground water development and crop management and preferably on a water-shed basis.

There is no clear association between holding size and rice yields is most of the districts of Bihar. It is true that the low yield plateau region has got relatively bigger holdings than the plains but the low yields are due to poor irrigation facilities. Between the two regions, there is little difference in holding size, but still south plains districts have got higher yields because

of much better irrigation coverage. So differential irrigation facilities in districts with similar size holdings has confounded the impact of holding size in yields.

With regard to energised pumpsets also, we find that the south plains are far ahead of the other two regions. The plateau region has the lower number of unit per 10,000 hectares. The yield levels are thus positively associated with the degree of energisation at the regional level. At the district level, however, this association is observed only in 9 districts due to the confounding impact of other factors.

Commercial Bank credit per ha. is much higher in the two plains than in Chotanagpur plateau. In Patna district, the per ha. credit is as high as Rs. 769 compared to just Rs. 33 in Santhal Parganas. The state average is Rs. 154. Within each region, however, there is not much variation and further there is little difference between the two plains also.

3.1.2. *Orissa*

Orissa is divided into four ecological regions : the northern plateau, central table land, eastern ghat and the coastal tract. Rice yields are relatively higher in the coastal areas followed by the central table land (Table 3.5). These regions have better irrigation facilities compared to the other two. In the northern plateau and eastern ghat, rice is largely rainfed and so the yields are comparatively lower. The inter-regional or inter-district variations in yields are, however, smaller in Orissa, as compared to the other three eastern states. There seems to be a better coverage of HYVs in many districts but in some, their impact on yield is less. HYVs as well as irrigation appear to have made a better impact in the two coastal districts viz., Cuttack and Ganjam. At Puri, the yield is low in spite of high irrigation level and fairly high HYV coverage. This could be partly due to the water-logging conditions and poor drainage which are possibly more serious in Puri than in the other coastal districts. In Balasore the yield is about average, though the input levels are below the state averages.

Next to the coastal tract, yields and input levels are higher in the table land. This area is also affected by poor drainage in the low lands as well as soil erosion by surface run-off in the uplands.

Eastern ghat is, in fact, the worst eroded tract in the state. Irrigation has made little headway in two among the three districts, though HYV levels are close to those of the table land. The impact of the latter on yield is, however, less in the absence of the complementary input of irrigation. Moreover, the soils are less fertile here. The soils in Phulbani are lateritic, while they are sandy in Koraput.

In the northern plateau which is a continuation of the Chotanagpur plateau, only Mayurbhanj district has got good average yield, while in the other two districts (Keonjhar and Sundergarh), the yields are low which may be attributed to the very low input levels. Undulating topography and light textured soils are some of the constraints to the spread of irrigation and modern inputs and realisation of better yields. Soil erosion, cultivation by hill tribes are some of the other constraints.

In Bihar as well as Orissa, supply outlets for HYV seeds, fertiliser etc., are woefully inadequate particularly in the plateau regions, due to poor transport net-work, insufficient seed multiplication facilities etc. These infrastructural bottlenecks hamper the spread of even the available technology and so high priority need to be given into strengthening of these facilities at the earliest.

The holdings in Orissa are a little bigger than those of east UP. The holdings are comparatively smaller in the coastal districts which have higher yields. This of course is not only due to the smaller size of holdings but also better irrigation and more fertile soils. On the other hand, in the northern plateau, the average size is smaller compared to the Central table land but the yields are lower because of very low irrigation ratios. So the provision of irrigation to areas abounding in small farms is the surest way of keeping in-tact their productivity advantages in relation to the bigger farms and satisfy the principle of both equity and efficiency. The above point is further supported by the fact that there is a clear impact of energised tubewells and pumpsets on the yields of rice in the districts. The rankings of the two variables are positively correlated. The association is closer than that between yields and the per cent of area irrigated (which includes all sources of irrigation). This emphasises the importance of the quality of irrigation as represented by powered tubewells and pumpsets.

The degree of energisation is higher in the coastal tract and central table land than in the plateau or ghat regions. In the coastal tract, energisation is lowest in Puri, where the yield also is low. The supply of bank credit again is larger in the high yield regions—the coastal and table lands than in the other two regions.

3.1.3. *East Uttar Pradesh*

In east U.P., rice is almost entirely rainfed in 9 out of 15 districts. In 4 other districts also, the per cent of rice area irrigated is quite low, ranging from 10 to 20% (Table 3.5). Only in Varanasi and Mirzapur, it is above 60%. It is somewhat surprising that, inspite of such low irrigation percentage—in fact, the lowest among the four eastern states,—the per cent of area under HYVs is the highest. In fact, HYV coverage bears little relation with the irrigation percentage even at the district level in east U.P.

Irrigation, because of the existing low level, has a relatively better impact on yields than HYVs. Further, HYVs seem to be available also for rainfed paddy in east U.P. as indicated by the fairly high adoption rates in many rainfed districts.

Among the 7 districts having higher yields (more than 10 quintals/ha), only 3 (Varanasi, Deoria and Allahabad) have more than 10% of their rice area irrigated. In Ghazipur and Mirzapur, the yields are low, though the irrigation levels are comparatively very high.

Some of the main causes for the above discrepancies are again found in water-logging in most of the low-

alkaline) soils. The latter are found in all the 3 districts of the upper Gangetic plain (Pratapgarh, Allahabad and Sultanpur).

The average cultivated holding is less than 1 ha in most of the districts in east U.P. indicating the preponderance of small and marginal farmers (Table 3.5). There is not much of inter district variations in the mean holding size to study the effect of farm size on productivity. Still, even within the limited range, it appears that districts with very small holdings are at an advantage over others with regard to the produetivity of rice. There is an inverse relationship between the average holding size and yields in 11 out of 15 districts. This is quite understandable in view of the fact that the rice produetion environment is still characterised by a labour-intensive technology with relatively smaller diffusion of capital or current inputs and therefore, smaller sized farm may have an advantage in this regard, with more family labour available per ha.

It is well realised that power availability for pumpsets and tubewells is a most crucial input for raising produetivity. In east U.P. there are just 2 energised pumpsets per 100 ha. of gross cropped area as compared to the all India average of 9.3. In the other 3 States, the situation is still worse.

Energisation and rice yields are seen to be correlated in 9 out of 15 districts. This cannot be considered as too close an association. It may be partly due to the erratic and uncertain power supply inspite of the pumpsets being apparently energised and partly due to the fact that the other alternative viz. diesel pumpsets may be as efficient as, if not more, than, the electric ones. The adverse influence of other factors like salinity of water cannot also be ruled out. The districts whose yields do not match with the degree of energisation are Ghazipur, Faizabad, Basti and Ballia. Some districts have done well inspite of a relatively lower position regarding energisation. This could be ascribed to other favourable factors including the one that dieselised pumpsets, though more costly, are probably under better control of the farmer.

The commercial banks even now contribute only a minor portion of the total borrowings of the farmer, even-though this proportion has somewhat increased over time. The yields of rice and per ha. commercial bank credit has broadly been seen to be positively associated. Cooperative societies have made greater strides in this regard, compared to commercial banks. A major reorientation in bank policies from asset-based loans to production-and purpose-based ones is yet to be achieved. The importance of institutional credit for modernisation of agriculture especially in the case of small and marginal farmers cannot be over emphasised.

3.1.4. *West Bengal*

West Bengal consists of the following regions : West Bengal plains, the plateau, Himalayan West Bengal and Dooar. Eleven districts are in the plains and only 4 are distributed in the other three regions. Yields in the latter are lower than in the plains, though they are higher than those of the plateau regions in the other 3 states (Tables 3.3 to 3.5).

The higher yields in the plains are generally associated with higher input levels while those in the other regions are below the state averages. In the plains also, a few districts (Malda, West Dinajpur and 24 Parganas) have lower yields associated with lower irrigation and HYV coverage. So, if the input levels in these districts can be pushed up, one can expect a rise in the yields.

Some districts have soil or other ecological problems adversely affecting the spread of modern inputs. For instance, Bankura and Midnapore have lateritic, acidic and eroded soils. So, HYV and yield levels are not commensurate with irrigation coverage. 24 Parganas, a coastal district has the low-lying Sunderban area, saline soils and is subject to floods. Purulia has gravelly soils. In Cooch Behar, large areas get waterlogged during rains and the soils are acidic. Poor yields in this district, can often be attributed either to heavy floods or drought conditions. It is necessary to explore minor irrigation sources in the low irrigation districts like Cooch Behar, Darjeeling, Malda and West Dinajpur. For undulating areas, modern methods of irrigation like drip or sprinkler system will be of great help in economising water use and cutting down running costs.

There is not much variation in the average size of holdings among the districts of West Bengal (Table 3.6). However, in the high-yield plains region, there are 7 out of 11 districts with holdings of 1 ha or less, whereas in the 4 hilly and plateau districts, holdings are all above 1 ha and 2 of them are above 2 ha. In the four hilly districts, the per cent of rice area irrigated ranges from 3 to 16, whereas in the plains, it is about 16% in 8 out of 11 districts and above 40% in 3 districts. With regard to the energised pumpsets and tubewells also the plains are better placed. The district level yields and the degree of energisation were found to be associated and so also energisation and HYV coverage.

Even within the plains region, there is much variation in the number of energised units per 10,000 ha. In districts like Burdwan, Hoogli and Murshidabad, it is above 40 while it is less than 20 in Birbhum, Bankura and West Dinajpur. These inter-district disparities need to be narrowed down so that yields in the lagging districts may be stepped up.

There are also large variations in the supply of commercial bank credit per ha. It is noteworthy that in the Himalayan districts of Darjeeling and Jalpaigury, it is Rs. 600 to Rs. 700 which probably has largely gone to the tea plantations. In Purulia, the rainfed plateau district, bank credit is as low as Rs. 45 per ha. In the plains, it ranges from Rs. 43 (Midnapore) to Rs. 613 (Hoogli). A more even distribution of bank credit will also help in bringing down inter-district variations in investments and in yields.

3.1.5. *Conclusions*

Based on the above analysis and the field investigation reports, the following strategies would seem to be appropriate for the various regions in eastern states :

(1) More effective flood control measures in the Bihar plains, especially in the Northern plains, coastal districts of Orissa and West Bengal and Gangetic plains in east U.P.

(2) Speedy construction of field channels and drainage channels in the canal command areas of the four states, preferably in conjunction with land consolidation programmes.

(3) Regulated water supply in the commands by provision of shutters and other devices and the introduction of Warabandi system to promote efficiency as well as equity in water distribution

(4) Erosion control in the plateau regions of Bihar, Orissa and West Bengal, through soil conservation programmes including terraced cultivation, afforestation on hilly slopes, pasture development on fallow or waste lands, inter-cropping etc.

(5) Soil amelioration programmes in areas with problem soils like acidity in the plateau regions, salinity and alkalinity in several east U.P. and north Bihar plains districts.

(6) Development of infrastructural facilities like sale outlets, roads, seed multiplication farms, credit facilities, etc. to step up the supply and distribution of modern inputs like new seeds, fertiliser, diesel, power, etc. more equitably among different regions and different sections of the farm community.

(7) Ground water development programmes with emphasis on modern methods like drip and sprinkler systems in undulating areas of water scarcity and on energisation of pumpsets in undulating areas of water scarcity and on energisation of pumpsets and tubewells.

(8) Research emphasis on developing new paddy varieties more resistent to floods/droughts, and suited to lowland/upland situations.

(9) Promotion of inter-cropping of cereals, and pulses/oilseeds especially on uplands.

TABLE 3.1

Yields of Rice, Input Levels and Growth Rates in the Eastern Region

State	Average Yield of rice (Kg./ha) 1980—82	Percentage of rice area		Growth rate of rice yield (80's over 70's)
		Irrigated (1980-81)	Under HYV (1980-81)	
Bihar .	899	34	25	0.3
Orissa .	977	29	31	1.2
Eastern U. P.	934	11	50	2.9
West Bengal	1,280	23	28	0.5
Eastern Region	1,034	26	31	0.8
All India .	1,322	40	46	1.8

TABLE 3.2

Distribution of Districts in Eastern States by Yield levels and Growth Rates for Rice

Yield levels (kg/ha) 1980—82	Growth Rates (80's over 70's)			
	<0%	0.1 to 2.0	>2%	Total
Bihar				
401—800 .	4	3	0	7
801—1200 .	6	2	1	9
>1200 .	0	1	0	1
Orissa				
401—800 .	0	0	0	0
801—1200 .	3	7	3	13
>1200 .	0	0	0	0
East U. P.				
401—800 .	1	1	0	2
801—1200 .	0	1	11	12
>1200 .	0	0	1	1
West Bengal				
401—800 .	0	0	0	0
801—1200 .	4	2	0	6
>1200 .	2	5	2	9
Eastern Region				
401—800 .	5	4	0	9
801—1200 .	13	12	15	40
>1200 .	2	6	3	11
Total .	20	22	18	60

TABLE 3.3

Yields, Input Levels and Growth Rate for Rice in Bihar Districts

Districts	1980—82 Yield (kg./ha)	1980-81		Growth Rates in 80's over 70's			Average size of operational holdings in ha. (1976-77)	Irrigated pump sets and tube-wells energised on 31st March 1981 per 10,000 ha.)	Per ha bank credit in agriculture, 30 June, 1980 (Rs.)
		%of rice area irrigated	% of rice area under HYV	Yield	Irrigated area	HYV area			
1	2	3	4	5	6	7	8	9	10
Northern Plateau									
Champaran	1,061	34	76	2.7	2.4	25.0	1.0	19	171
Purnea	802	13	57	0.8	2.6	39.0	1.1	23	155
Muzaffarpur	787	11	16	1.2	20.5	30.9	0.6	98	201
Saran	779	10	9	—1.1	21.8	12.2	0.8	62	202
Dharbhanga	763	8	21	—0.3	4.1	26.3	0.7	53	160
Saharsa	681	33	37	0.8	5.6	28.7	1.4	18	136
South Plains									
Sahabad	1,342	92	24	1.6	0.5	1.4	1.2	257	133
Patna	1,153	91	55	—1.6	2.0	13.2	0.8	663	769
Bhagalpur	1,057	71	30	—0.8	—1.3	35.2	1.0	95	162
Gaya	837	99	19	—0.7	1.4	5.8	1.0	471	91
Monghyr	823	48	25	—0.5	0.4	20.7	0.9	205	149
Chotanagpur Plateau									
S. Parganas	956	71	3	0.4	—3.0	11.2	2.0	21	33
Dhanbad	953	1	2	—0.5	—12.2	—1.1	1.4	79	36
Singhbhum	862	4	4	—0.3	—3.6	26.8	1.5	7	31
Hazaribagh	773	1	11	0.8	—4.7	15.2	1.7	46	64
Ranchi	717	3	5	—0.7	1.3	11.2	2.5	17	50
Palamau	634	15	6	—0.7	115.6	—2.5	1.9	113	101
Bihar	899	34	25	0.3	1.1	16.8	1.1	143	154

TABLE 3.4

Yields, Input Levels and Growth Rates for Rice in Orissa Districts

Districts	1980—82 Yield (kg./ha.)	1980-81		Growth rates (1980's over 70's)			Average size of operational holdings in ha. (1976-77)	Irrigation pump sets & tubewells energised on 31 March 1981 (per 10,000 ha.)	Per ha. bank credit for agriculture, 30th June 80 Rs.)
		% of rice area irrigated	%of rice area under HYV	Yield	Irrigated area	HYV area			
1	2	3	4	5	6	7	8	9	10
Northern Plateau									
Mayurbhanj	977	11	24	2.8	2.3	35.4	1.7	6	27
Keonjhar	834	9	12	0.6	9.3	23.0	1.6	9	42
Sundergarh	807	7	20	0.2	2.1	25.2	1.7	18	56
General Table Land									
Dhenkanal	1,000	14	30	1.5	0.4	25.2	1.4	36	48
Bolangir	965	26	29	1.1	—0.3	16.8	2.1	40	172
Sambalpur	1,103	39	41	1.0	—0.5	13.3	1.9	12	130
Eastern Ghat									
Koraput	926	6	27	1.3	—4.2	29.4	2.4	10	86
Phulbani	922	32	39	—4.2	0.5	27.7	1.5	6	73
Kalahandi	824	11	30	—0.1	9.0	36.0	2.6	4	39
Coastal tract									
Ganjam	1,148	64	56	1.4	4.3	27.8	1.1	32	124
Cuttack	1,045	42	34	2.5	0.7	45.8	1.3	25	231
Balasore	966	21	15	2.7	1.7	20.9	1.5	31	52
Puri	907	35	33	—1.8	6.6	25.6	1.1	7	514
Orissa	977	29	31	1.0	2.1	21.0	1.6	19	136

TABLE 3.5

Yields, Input Levels and Growth Rates for Rice in East U. P. Districts

District	1980—82	1980-81		Growth Rates (80'2 over 70's)			Average size of operational holdings in ha. (1976-77)	Irrigation pump sets and tube-wells energised on 31st March, 1981 (per 10,000 ha.)	Per ha. bank credit for the agriculture, 30th June 1980 (Rs.)
	Yield kg./ha.	% area irrigated	% area under HYV	Yield	Irrigated area	HYV area			
1	2	3	4	5	6	7	8	9	10
Middle Gangetic Plains									
Varanasi	1,318	61	44	5.9	6.5	2.0	0.6	324	198
Faizabad	984	10	79	2.1	15.7	7.7	0.7	262	101
Ghazipur	843	19	39	3.9	15.7	9.6	0.9	367	177
Azamgarh	1,035	3	58	6.0	—2.2	7.2	0.6	343	134
Deoria	1,119	12	53	4.3	65.9	7.1	0.8	106	202
Jaunpur	1,102	1	47	6.4	—1.4	9.9	0.5	365	151
Gorakhpur	1,026	1	63	2.1	—6.2	9.8	0.8	83	251
Basti	774	2	44	0.8	9.8	6.7	—	100	111
Ballia	837	2	40	1.0	12.0	6.4	0.9	212	221
Mirzapur	946	69	41	2.6	6.2	13.9	1.6	62	110
Gonda	802	0	54	2.2	27.6	7.7	0.9	57	82
Baharaich	551	0	33	—0.8	—0.5	14.1	1.0	15	56
Upper Gangetic Plains									
Pratapgarh	1,125	1	35	5.1	—26.0	8.2	0.6	167	87
Allahabad	1,038	17	41	2.8	11.1	3.8	1.0	183	120
Sultanpur	882	1	63	2.8	—20.4	10.7	0.7	142	161
East U. P.	934	11	50	2.9	7.3	8.0	1.0	200	143

TABLE 3.6

Yields, Input Levels and Growth Rates for Rice in West Bengal Districts

District	1980—82	1980-81		Growth Rates (80's over 70's)			Average size of operational holdings in ha. (1976-77)	Irrigation pump sets & tubewells energised on 31st March 1981 (per 10,000 ha.)	Per ha. bank credit for agriculture, 30th June, 1980 (Rs.)
	Yield kg. /ha.	% Irrig. area	% area under HYV	Yield	Irrigated area	HYV area			
1	2	3	4	5	6	7	8	9	10
West Bengal Plains									
Birbhum	1,518	43	35	—0.01	0.4	11.6	1.2	19	119
Burdwan	1,642	47	48	0.7	0.1	6.4	1.2	40	239
Hooghli	1,784	42	57	0.9	0.5	1.9	0.8	49	613
Bankura	1,321	32	20	—0.04	—1.2	9.9	1.1	9	73
Midnapur	1,184	21	23	—0.2	11.0	2.0	0.8	16	63
Howrah	1,360	21	32	0.3	15.3	1.2	0.5	22	205
Murshidabad	1,365	21	31	2.2	1.9	8.2	0.9	51	176
24-Parganas	1,218	13	26	1.3	25.9	5.6	0.8	26	233
Malda	1,265	14	25	1.9	—10.5	6.9	0.9	41	145
West Dinajpore	959	7	15	—1.0	23.1	3.2	1.3	20	93
Nadia	1,389	19	40	3.6	22.3	12.5	1.0	38	310
W.B.Plateau									
Purulia	1,177	16	17	0.3	9.4	3.0	1.1	—	45
Himalayan W.B.									
Darjeeling	1,199	8	37	0.9	3.5	5.3	2.7	8	696
W.B. Dooar									
Jalpaiguri	1,009	13	10	—1.5	29.7	—7.0	2.0	11	633
Cooch Bihar	984	3	16	—0.7	55.1	15.0	1.1	11	103
West Bengal	1,280	23	28	0.5	4.0	5.2	1.0	33	200

CHAPTER IV

PRODUCTIVITY OF WHEAT IN THE EASTERN REGION

4.1. Region

The average yield of wheat in the eastern region during 1980—82 was 14.3 quintal/ha. compared to 16.6 quintal/ha. for all India. The productivity of wheat, however, is 4 quintal more than that of rice in the region due to better technological advancement in regard to wheat and its cultivation under controlled water supply in the rabi season.

The yield levels of wheat are comparatively higher in Orissa (18.6 quintal/ha) and West Bengal (17.4 quintal) than in Bihar (13.3 quintal) and east U.P (14.5 quintal). This ranking is more or less similar to the case of rice, except that the first and second positions have been reversed. The differences in average yields are also more in regard to wheat. The distribution of districts by yields suggests that most of Bihar districts are in the low yield category (<14.00 quintal) while most of east U.P. districts are in the medium yield group (14 to 18 quintal/ha). Almost all the districts in West Bengal and Orissa belong to the medium and high yield groups.

Regarding the rates of growth in wheat yields between the 70's and 80's, east U.P. has again performed best, as in the case of rice, achieving a growth rate of 3.5%, while Orissa had a modest growth rate of 1.4%. In contrast, West Bengal and Bihar had negative growth rates (—1.4% and —0.5% respectively). The distribution of districts also shows that majority of the districts had growth rates above 2% in east U.P., while in Orissa, growth rates ranged from 0 to more than 2%. In contrast, West Bengal had two-thirds of the districts with negative growth rates while most of the districts in Bihar had either negative or low growth (below 2%) rates. The fact that West Bengal and Orissa are chiefly rice consuming States and the competition of winter and summer rice to wheat could also have induced lower growth rates in wheat yields in the above two States, compared to east U.P. which consumes more of wheat. In fact, the area under wheat in the last two States constitutes 93% of the total wheat area in the eastern region. Another factor that has contributed to this difference is the much lower yield base of east U.P. and Bihar in the 70's. Orissa, however, has achieved more or less equal (albeit modest) growth rates in wheat and rice. The growth rate of wheat yield in the eastern region as a whole has been only a low 0.9% compared to 2.2% for All-India.

Combining growth rates and yield levels, we find that a large number of districts in West Bengal, belong to medium to high yield and negative growth categories, while most of Orissa districts are in medium to high yield and low to high growth groups while Bihar districts are mostly in low yield and negative-to-low growth categories. In East U.P. District are mainly in medium yield-nigh growth category.

In contrast to the low level of irrigation for rice in the region (only 25% of the area is irrigated), the area under wheat is largely irrigated (81%). Only in West Bengal, the irrigation percentage is very low (27%). Similarly HYV coverage also is quite high (77%) in the eastern region which is almost equal to the percentage for all India. Orissa and West Bengal in which area under wheat is very limited, almost the entire area is covered by HYVs. In spite of such high input levels, the yields in the eastern region, particularly in east UP and Bihar are lower than the national average, though in Orissa and West Bengal they are higher.

In the following sections, we present a districtwise and regionwise analysis of wheat yields and some of their major determinants. We confine ourselves to two States viz. Bihar and East U.P. which together, account for 93% of the wheat area in the eastern region. The variables taken for the analysis are the same as those used for rice.

4.1.1 *Bihar*

Virtually the whole wheat area is concentrated in the north and south plains of Bihar, the share of Chotanagpur plateau being just 4%. The yields of wheat are also higher in the two plains than in the plateau (Table 4.3). There is, however, little difference in yields between the two plains. It is noteworthy that there is less of inter-district variations in the yields of wheat compared to those of rice. All the yields are above 10 quintal/ha. and the range is upto 15 quintal/ha. The two major factors contributing to the higher and more stable yields of wheat are (*i*) cultivation in the rabi season under much higher and more uniform levels of irrigation facilitating regulated water supply and (*ii*) better technological advancement in the case of wheat.

The percentage of wheat area under irrigation in Bihar is 72% compared to just 34% in the case of rice. The irrigation percentage is above 60% in all districts except Bhagalpur and the highest is 94% in Santhal Parganas. Similarly, the per cent of wheat area under HYV is also quite high (72%) in the state, in contrast to 24% for rice. The HYV ratio ranges from 60 to 100% in most of the districts. The HYV coverage is greater in the north plains districts than the other regions though it is not perceptable in terms of yields. The impact of HYVs on yields seems to be less in the north plains than in the South plains as indicated by the fact that the yield ranks of all but one district in the former are less than their corresponding ranks in HYV percentage, while it is reverse in the south plains districts. This may be because of alkaline soils found in many of the north plains districts, while the soils in the south are less affected by alkalinity or acidity.

The districts with the lowest yield ranks in the north plains (Muzaffarpur and Saharsa) have got 'Usar' soils

while Purnea with the next low rank has acid soils. Similarly in the south plains, Bhagalpur and Gaya which have low yields have also got saline and alkaline soils though to a smaller extent than the north plains districts mentioned above. On the other hand, two districts (Patna and Monghyr) have highest yields though their input levels are lower. One possible explanation for this is that these two districts have got very fertile 'diara' lands along the Ganges which are most suited to wheat cultivation. There may be other factors also responsible for the differences in yields. Because of the influence of other factors like the ones mentioned above, yield and irrigation levels were matching only in 6 out of 13 districts, yield and HYV coverage in 6 districts, irrigation and HYV in all the 13 districts.

In Chotanagpur plateau the wheat yields are low possibly because of the less fertile acidic soils, its drought-proneness and uncertain sources of irrigation. Because of these reasons, the area under wheat is also very limited (except Palamau and S. Parganas, the share of other districts in the total wheat area of the state is less than 1% each). In contrast, the plains have not only got more fertile soils but also have brought more area under tube-wells which are largely used for irrigating wheat and are responsible for the higher yields.

The growth rates in wheat yields over the last decade have been in general low and in several districts, negative, in spite of higher growth rates in the area covered by irrigation and HYVs. The input growth rates have been relatively greater in the north plains but with no proportionate impact on yields. This may be due to the reasons mentioned above. It is possible that with the extension of irrigation, less fertile lands have been brought into cultivation resulting in a decline in yields. Also the demand for HYV seeds of wheat is much greater than its supply and due to the short supply of certified seeds, the farmers may be using seeds of inferior quality. Fertiliser shortage and lack of sufficient sale outlets may also be responsible for not realising the full potential of HYV seeds.

4.1.2. *East Uttar Pradesh*

Compared to Bihar, there is a better impact of irrigation and HYV levels on wheat yields in east U.P. The input coverage is also greater. The average yield for east U.P. is 1.2 quintal/ha. more than that of Bihar and the percentages of area under irrigation and HYV are 86 and 76 respectively compared to 79 and 72 in Bihar (Table 4.4). However, the mean yield of wheat in east U.P. (14.6 quintal/ha.) during 1980—82 was 2.7 quintal less than that in West U.P. and 2 quintal less than the all India yield, in spite of a higher percentage of wheat area under irrigation, as against 82% in West U.P. and only 70% for all India. The HYV percentage, however, is slightly less in east U.P. (76%) than in the West Uttar Pradesh (79%) and all India (78%). The lower impact of modern inputs on yields in east U.P. compared to West U.P. or Punjab may be partly ascribed to the inferior quality of irrigation in east U.P., particularly the lower percentage of irrigated area under private tubewells.

The districtwise picture in east U.P. reveals that yields and irrigation percentage are matching in 12 out of 15 districts and yield and HYV coverage, in 11 districts. Irrigation and HYV percentages are matching in 13 districts.

The districts whose yields are not commensurate with irrigation and HYV coverage are Ghazipur, Basti and Pratapgarh. The district where yield is not commensurate with only HYV coverage is Azamgarh and the district where yield is not proportionate to irrigation level only is Varanasi. Among these, Ghazipur, Pratapgarh, Azamgarh and Varanasi have saline and alkaline soils which reduce the impact of irrigation, HYV and fertiliser. In Sultanpur where also these soils are present the yield level is, however, higher and in line with the input coverage.

Since this particular type of problem soils is found largely in the north plains of Bihar and middle and upper Gangetic plains in east U.P. adversely affecting the productivity of both rice and wheat, systematic steps need to be taken to tackle this problem on a priority basis. These soils are called 'reh' or 'usar' in U.P. and are characterised by a hard pan in the subsoil impeding the downward movement of water. These soils however are observed to respond favourably to reclamation techniques including mechanical shattering of hard pan of the subsoil, leaching out salts with the help of adequate drainage and growing of salt-tolerant crops like castor, barley and even sugarcane. Light dressings with gypsum or calcium chloride are effective treatments for these soils.

Ground water development in conjunction with soil amelioration programmes are sponsored and financed by NABARD. It is not known to what extent such schemes have been implemented in the eastern States.

Compared to Bihar, the growth rates in yields as well as input levels have been 3.5% on average and varies from 1 to 5% in the various districts. The average growth rate has been in fact, higher than that for West U.P. (2.9%) or all India (2.2%). The growth of irrigated area has been 8.6% and that of HYV area, 11.4% in east U.P. as compared to 4.3% and 9.5% respectively for West U.P. So the growth performance of east U.P. has been good in respect of both rice and wheat and this is partly because of the comparatively lower yield and input levels in the base year.

West Bengal and Orissa have been omitted in this analysis since their wheat areas constitute only 5.4% and 1.4% of the wheat area in the eastern region. They are primarily rice producing states and wheat occupies only a marginal place in the cropping pattern of these states. The yield levels are, however, higher in them —18.6 qtl./ha in Orissa and 17 qtl./ha. in West Bengal, possibly in response to nearly 100% coverage under HYVs. Orissa had also a moderate growth rate of 1.4% in yields. West Bengal however had a negative growth (—1.4%) in yields. West Bengal is said to be facing some soil problems, adversely affecting the productivity of wheat. There is also the competition of summer (boro) rice for wheat. So it appears that a major thrust for raising the productivity of wheat has to be made in the two chief wheat producing states viz. east U.P . and Bihar as well as in selected districts of the other two States.

4.1.3. *Conclusions*

The productivity of wheat has been in general, higher than that of rice in the four eastern states, due to better coverage under irrigation and HYV. However, the area under wheat has b en much smaller than that of rice except in east U.P. where it is fairly close to the rice area. With the extension of irrigation, the area under wheat is bound to go up. This will help to raise the cropping intensity in these states and lead to a relatively more diversified and profitable cropping pattern, nullifying, to some extent, the risk element involved in placing too much emphasis on the rice crop which suffer from greater yield fluctuations. It will also help in absorbing more labour-family and hired-more gainfully, all the year round. Above all, it will help the eastern states to participate in and share the gains of the wheat revolution now largely confined to Punjab, Haryana and West U.P. For the country also, this will be a big advantage in so far as wheat production will then have a much wider geographical coverage so that shortfalls in one area may be made up by gains in another. So while all efforts should be made to raise rice production in these areas, these should not be at the expense of wheat production.

The strategies to raise wheat production and productivity will be the following :—

1. Financing and subsidising the construction of private tubewells, dug-wells, sprinklers, energisation of pump sets etc., particularly for small and marginal farmers.
2. Tapping and/or fully utilising other sources like river lifts, tanks, public tubewells etc., at state expense.
3. Stepping up the production of certified seeds, fertilisers etc., in demand by farmers and opening of more sale outlets for their distribution.
4. A massive programme for treatment of saline and alkali soils in the affected districts, with financial assistance to the small and marginal farmers. Chemicals for this purpose also should be made available at the doorsteps of the farmers.
5. Strengthening of extension system like T & V for more effective dissemination of research information and for cooperative control of pests and other problems.
6. Research emphasis on drought and pest resistant HYVs for wheat.

TABLE 4.1

Yields of wheat, Input levels and Growth Rates in the Eastern Region

State	Average yield of wheat (1980--82) Kg/ha	Percentage of Wheat area		Growth rate of wheat yield (80's/70's)
		Irrigated	Under HYVs (1980-81) Kg/ha	
Bihar	1,328	79	72	—0.5
Orissa	1,860	96	100	1.4
East. U.P.	1,461	86	76	3.5
West Bengal	1,736	27	99	—1.4
Eastern Region	1,432	81	76	0.9
All India	1,660	70	78	2.2

TABLE 4.2

Distribution of Districts in Eastern States by yield levels and Growth Rates

State	Yield level (Kg./ha) (1980—82)	Growth rates (80's over 70's)			
		0%	0.1 to 2.0%	2.0% or more	Total
Bihar	1400	7	5	2	14
	1401—1800	1	1	1	3
	1800 & above	0	0	0	0
Orissa	1400	1	0	0	1
	1401—1800	1	2	3	6
	1800 & above	1	2	3	6
East U.P.	1400	0	2	2	4
	1401—1800	0	2	9	11
	1800 & above	0	0	0	0
West Bengal	1400	0	0	0	0
	1401—1800	7	1	1	9
	1800 & above	3	1	2	6
Eastern Region	1400	8	7	4	19
	1401—1800	9	6	14	29
	1800 & above	4	3	5	12
Total		*21*	*16*	*23*	*60*

TABLE 4.3

Yields, input levels and growth rates for wheat in Bihar Districts

Districts	1980—82 yield (kg/ha)	1980-81		Growth rate (1980's over 70's)		
		%area irrigated	%area under HYV	Yield	Irrigated areas	HYV areas
North Plains						
Darbhanga	1,430	59	74	—2.7	7.7	12.8
Saran	1,377	90	83	—5.7	6.9	23.6
Muzaffarpur	1,222	64	83	1.2	11.9	18.0
Purnea	1,363	73	75	0.01	14.4	4.8
Saharsa	1,144	85	86	0.01	3.0	3.7
Champaran	1,369	67	100	2.2	2.4	5.7
South Plains						
Bhagalpur	1,084	47	45	—6.0	13.3	8.9
Shahabad	1,374	88	60	—2.2	2.0	3.1
Gaya	1,165	68	50	—2.1	8.6	12.4
Monghyr	1,474	63	71	0.01	10.2	14.7
Patna	1,435	89	63	2.7	6.3	6.6
Chotanagpur Plateau						
Palamau	1,007	60	38	—3.2	7.6	37.9
S. Parganas	1,097	94	74	—2.6	15.1	23.6
Bihar	1,328	79	72	—0.5	6.8	9.5

NOTE—4 districts in the C. Plateau are omitted since their share in the total wheat area of the State was less than 1% each.

TABLE 4.4

Yields, input levels and growth rates, for wheat in east U.P. districts

Districts	1980—82 yield (kg/ha)	1980-81		Growth rates (80's over 70's)		
		%irri. area	% area under HYV	Yield	irrigated area	HYV area
Middle Gangetic Plains						
Varanasi	1,418	99	70	3.2	12.1	13.1
Faizabad	1,785	96	90	5.0	6.3	9.3
Ghazipur	1,504	96	89	3.9	16.0	21.6
Azamgarh	1,487	95	87	2.0	16.1	17.6
Deoria	1,647	96	86	4.8	6.7	11.3
Jaunpur	1,782	98	81	3.2	10.8	14.3
Gorakhpur	1,481	93	81	3.9	4.9	8.5
Basti	1,366	94	81	1.9	4.2	7.4
Ballia	1,510	87	71	1.1	11.8	15.9
Mirzapur	871	58	41	2.0	13.6	22.1
Gonda	1,348	67	62	4.1	7.8	3.5
Bahraich	1,218	45	36	3.9	7.9	4.4
Upper Gangetic Plains						
Pratapgarh	1,442	97	89	2.5	14.8	15.0
Allahabad	1,446	83	79	2.8	9.4	14.6
Sultanpur	1,522	96	88	2.9	8.1	10.6
Eastern U.P.	1,461	86	76	3.5	8.6	11.4

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CHAPTER V

POTENTIAL IN THE EASTERN REGION

5.1. Introduction

This chapter deals with the discussion on potential in the rice and wheat yields in Eastern Region of India. For this two alternative approaches have been discussed In the first approach the results of experiments on cultivators fields specially obtained from Indian Agricultural Statistic Research Institute for the study Group have been utilised. The additional produce has been estimated by taking the differences in the economically optimum yields under experimental conditions on cultivators' fields and average yield as actually observed. The expected additional produce as estimated through first alternative can be achieved by proper extension effort taking the technology to the farms. But this has implications in terms of higher demand for inputs and infrastructure. In the second approach the States of the region have been divided according to agro-climatic zones and in each zone, the average yield is then compared with the highest yield obtained in a district falling in that zone. In this alternative the potential can be achieved by providing infrastructure and inputs at par with the best district in each agro-climatic zone.

The results under these alternatives are discussed in the following sections.

5.2. Alternative—I

Under the All-India Coordinated Research Project of Indian Council of Agricultural Research, experiments are conducted on cultivators' fields in selected districts spread over the entire country to study the response of fertiliser on crops under normal farming conditions. For the purpose of conducting the experiments a stratified multistage random sampling design has been adopted. The experiments consisted of the treatments, control, (no fertiliser). N_{40} P_{20} K_{20}, N_{80} P_{40} K_{40} and N_{120} P_{80} K_{80}.

Where N, P and K denote nitrogen, phosphorus and Potassium and the suffixes denote the levels of nutrients in kg/ha. Data on rice and wheat for the period 1979-80 to 1981-82 have been utilised. The data were analysed for individual years following the appropriate statistical methods and response to various nutrients obtained for each district. The district average were pooled over the years and a quadratic response function fitted on the pooled data to estimate the response at different levels. From these the response to economic optimum dose of inputs have been worked out. This has been termed as potential.

The Districts of Eastern Region covered under the project area

State	Districts
East U.P.	Azamgarh, Faizabad and Jaunpur
Bihar	Muzaffarpur and Purnea
Orissa	Ganjam and Phulbani

Data of fertiliser response are available for Muzaffarpur and Purnea districts of Bihar, Ganjam and Phulbani districts of Orissa and Azamgarh, Faizabad and Jaunpur districts of Uttar Pradesh. The results of rice and wheat are discussed below :—

5.2.1. *Rice*

It is important to mention that these experiments on the selected cultivators are conducted with HYV varieties and better management practices like pest and weed control measures, proper irrigation. The estimates of additional yields have been worked out by taking the difference in the optimum yields as estimated under experimental conditions for treatment combinations and the average yields observed for the years 1980—82. The results are presented in Table 5.1. On the basis of these it is observed that for economic optimum dose of application of fertiliser in Muzaffarpur district of Bihar the potential estimated is 481 per cent. In Purnea district of Bihar the potential obtained is 587 per cent.

In Ganjam district of Orissa, the potential is 594 per cent. In Phulbani district the potential is estimated at 909 per cent.

In Azamgarh, the potential has been estimated at 315 per cent. In Faizabad, the potential is of the order of 347 per cent. In Jaunpur, the potential has been estimated at 397 per cent.

Eastern Region V/s Rest of the country

The results of other states for which similar data were available have been analysed with a view to compare the potential in Eastern Region with the rest of the country. Since results are not available separately for Eastern U.P. and rest of U.P; entire U.P. has been grouped with Eastern Region. The results are presented in Table 5.3. It can be seen from this table that the potential in Eastern Region is little over 400 per cent as compared to 244 per cent for the rest of the country. Further, in terms of optimum potential yield as also gap between optimum yield and actual yield Orissa ranks first followed by Bihar. Also, except for Madhya Pradesh, all other states have lower potential as compared to the States of Uttar Pradesh, Bihar and Orissa in the Eastern Region.

5.2.2. *Wheat*

The analysis relates to Bihar and Eastern U.P. as they are the major producers of wheat in the Eastern Region. (Table 5.2) In the Muzaffarpur district of Bihar, the potential in wheat is estimated at 361 per cent, whereas in Purnea district the same has been estimated at 255 per cent. In Faizabad district of Eastern U.P. the potential in wheat has been estimated at 166 per cent, in Jaunpur at 159 per cent and in Azamgarh at 211

per cent at the economic optimum dose of fertiliser application. It is, thus seen that the districts of Bihar have higher potential of increasing the yield as compared to East U.P.

The potential of wheat yield in Eastern Region is 220 per cent which is observed as highest when compared to other regions of the country Table 5.4. For the country as a whole this potential is estimated at 167 per cent. Further, the potential of wheat yield is highest for Bihar not only in the region but also for the country as a whole.

5.3. **Alternative—II**

5.3.1. *Rice*

The districts which had highest yield of rice in different zones during 1980—82 are tabulated below :—

Agro-climatic zones	Districts having highest yield	Yield (kg/ha)
Bihar		
1. North west alluvial plain	Champaran	1061
2. North east alluvial plain	Purnea	802
3. South Bihar alluvial plain	Patna	1153
4. Central and north east plain	Santhal Parganas	956
5. Western Plateau	Ranchi	717
Orissa		
1. North west plateau	Sambalpur	1103
2. North east coastal plain	Balasore	966
3. East and south east-coastal plain	Cuttack	1045
4. West central table land	Sambalpur	1103
East U.P.		
1. North east plain zone	Deoria	1193
2. Eastern plain zone	Varanasi	1318
3. Vindhyan zone	Allahabad	1038
West Bengal		
1. Terai zone	Jalpaiguri	1009
2. Old Alluvial zone	Hoogly	1784
3. New Alluvial zone	Nadia	1389
4. Red and laterite soil zone	Burdwan	1642
5. Coastal saline zone	Howrah	1360

Using the information on the highest yield in the zone with the average for the zone the addition to yield have been worked. The result have been aggregated at the state level and presented below :

TABLE A

Rice yield and the expected additional produce in the Eastern Region 1980—82

States	Weight	Average yield	Average highest yield	Additional produce (%)
East Uttar Pradesh	14.4	934.3	1184.00	26.8
Bihar	23.0	906.0	974.00	7.51
West Bengal	46.1	1280.37	1545.00	20.67
Orissa	15.6	976.51	1059.00	8.45
Aggregate		*1036.35*	*1281.00*	*23.60*

It can be seen that the eastern region has an expected additional produce of 23.6% in the rice yield. Further, the expected additional produce of rice yield is highest in East U.P. (26.8%) followed by West Bengal (20.67%), Orissa (8.45%) and Bihar (7.51%).

5.3.2. *Analysing the results statewise following observations can be made*

In East Uttar Pradesh, the highest expected additional produce of 31 per cent has been estimated in the north-east plain zone (Bahraich, Basti, Deoria, Gonda and Gorakhpur) followed by eastern plain zone (Azamgarh, Ballia, Faizabad, Ghazipur, Jaunpur, Pratapgarh, Sultanpur and Varanasi) where the expected additional produce was 29 per cent.

In West Bengal, the highest expected additional produce of 35 per cent has been estimated in the old alluvial zone (west Dinajpur, Malda, Murshidabad, Burdwan, Hoogly, Howrah and Midnapur) followed by red and laterite soil zone, new alluvial zone, central saline zone, where the expected additional produce have been worked out to the order of 21, 14 and 13 per cents respectively.

In the state of Orissa, the highest expected additional produce of 8 per cent has been estimated in the north-west plateau (Sundergarh and Sambalpur) followed by east and south east coastal plain, north-east coastal plain and west central table land, where the expected additional produce were 6.5 and 5 per cent each respectively.

In the state of Bihar the highest expected increase in yield by 22 per cent has been estimated in the south Bihar Alluvial plain (Bhagalpur, Gaya, Monghyr and Patna) followed by expected additional produce of 19 per cent in the north west alluvial plain (Champaran, Saran and Muzaffarpur). The expected additional, produce in the central and north east plateau, north east alluvial plain and western plateau were of the order of 16, 4 and 2 per cent respectively.

In order to work out the potential of increasing rice yield in Eastern Region vis-a-vis rest, the country has been divided into different regions—Eastern, Northern, Western and Southern. The states in different regions are as follows :—

Region	States
1. Eastern	Eastern Uttar Pradesh, Bihar, Orissa and West Bengal.
2. Northern	Haryana, Himachal Pradesh and Punjab.
3. Western	Gujarat, Madhya Pradesh, Maharashtra and Rajasthan.
4. Southern	Andhra Pradesh, Karnataka, Kerala and Tamil Nadu.

Of these four regions it is observed that the share of Eastern region in area under rice is 49 per cent and that of southern region is about 31 per cent. The potential in Eastern Region is about 38 per cent higher than that of Southern Region.

TABLE B

Expected additional produce of Rice : 1980—82

Region	Weight	Average yield kg./ha	Highest yield in the region kg/ha	Expected additional produce (per cent)
Eastern . . .	48.6	1,036	1,281	23.6
Southern . . .	30.6	1,957	2,291	17.1
Aggregate . . .		*1,391*	*1,671*	*20.1*

5.3.3. *Wheat*

The districts having highest wheat yield in different agro-climatic zones of Eastern Region during 1980—82 are as under :

Agro-climatic zones	Districts	Yield (kg/ha
1. Terai zone . .	Jalpaiguri	1,800
2. Old alluvial zone . .	West Dinajpur	2,136
3. New alluvial zone . .	West Dinajpur	2,136
4. Red and laterite soil zone	Midnapur	1,877
5. Coastal saline zone . .	Midnapur	1,877
East U.P.		
1. North-east plain zone .	Deoria	1,647
2. Eastern plain zone . .	Faizabad	1,785
3. Vindhyn zone . . .	Allahabad	1,466
Orissa		
1. North-west plateau . .	Sundergarh	2,236
2. North-east coastal plain .	Balasore	2,031
3. East and south-east coastal plain . . .	Cuttack	2,077
4. West Central table land .	Sambalpur	1,797
Bihar		
1. North-west alluvial plain .	Saran	1,377
2. North-east alluvial plain .	Purnea	1,363
3. North Bihar alluvial plain	Monghyr	1,474
4. Central and north east plain	Ranchi	1,244
5. Western plateau . .	Ranchi	1,244

Similar to that of rice the expected additional produce have been worked out at zone level and then aggregate at the state level. The results at the state level are as under :—

TABLE C

Wheat yield and the expected additional produce in the Eastern Region

State	Weight	Average yield	Average highest yield	Additional produce
East Uttar Pradesh	56.27	1,460.51	1,685.31	15.39
Bihar . . .	36.88	1,327.73	1,393.71	4.97
West Bengal .	5.40	1,734.41	2,081.52	19.94
Orissa . .	1.45	1,858.86	2,024.26	8.90
Aggregate . .		*1,432.16*	*1,604.18*	*12.01*

It can be seen that the Eastern Region has expected additional produce of 12.01 per cent in the wheat yield. Further, the expected additional produce is highest in West Bengal (19.94 per cent), followed by East Uttar Pradesh (15.39 per cent), Orissa (8.90 per cent) and Bihar (4.97 per cent).

Analysing the results statewise following observations can be made :—

In West Bengal, the highest expected additional produce of 22.37 per cent was observed in the new alluvial zone (West Dinajpur, Malda, Murshidabad, Nadia and 24 Parganas) followed by old alluvial zone, Red and laterite soil zone, Terai zone and coastal saline zone, where the expected additional produce were of the order of 21.83, 11.48, 4.17 and 3.24 per cents respectively.

In East Uttar Pradesh, the highest expected additional produce of 18.41 per cent was observed in the Vindhyan zone districts (Allahabad and Mirzapur) followed by North East Plain zone (Gonda, Bahraich, Basti, Gorkhapur and Deoria) and eastern plain zone where the expected additional produce were 16 and 14 per cents respectively. The expected additional produce of wheat yields in Western Uttar Pradesh plains was 25 per cent.

In Orissa, the highest expected additional produce of 21.55 per cent was observed in North-West plateau zone (Sundargarh and Sambalpur) followed by West central table land, east and south east coastal plain and north east coastal plain where the expected additional produce were of the order of 5.42, 4.35 and 2.93 per cents respectively.

In Bihar, the highest expected additional produce of 40 per cent was observed in the central and north east plateau zone (Hazaribagh, Santhal Pargana, Dhanbad and Ranchi) followed by Western plateau zone, north east alluvial plain, north Bihar alluvial plain and north west alluvial plain where the expected additional produce were of the order of 11, 7, 5 and 3 per cents respectively.

TABLE D

Expected additional produce of wheat

Region	Weight	Average yield kg/ha	Highest yield in the region kg/ha.	Expected additional produce (Per cent)
Eastern . .	24.2	1,432	1,604	12.0
Northern . .	32.2	2,521	2,833	12.4
Western . .	43.6	1,207	1,508	24.9
Aggregate . .		*1,689*	*1,958*	*15.9*

In case of wheat the analysis is confined to only three regions, Eastern, Northern and Western. Southern region has been left out as wheat is not an important crop in that region. It can be seen that the country has an additional potential of 15.9 per cent in wheat yield. Further, the expected additional produce of wheat in the eastern region is about of the same magnitude as that of Northern region but lower that of Western region.

5.3.4. *Conclusions*

It was observed through first approach that in terms of potential yields for rice, consistent with economic optimum, Orissa ranks first followed by Bihar. The same position holds in terms of gap between optimum yields and actual yields of rice. Further, through this approach it is also seen that the potential in Eastern Region, as a whole is little over 400 per cent higher than the actual yields, as against the corresponding figure of 244 per cent for the rest of the country. For wheat the potential has been estimated at 220 per cent which is highest as compared to other regions of the country. Further, the potential of wheat yield is highest for Bihar not only in the Eastern Region States but also in the rest of the country.

Through the second alternative it is seen that the eastern region has a potential of about 25% in the rice yields. The potential of rice yields is highest in East U.P. followed by West Bengal, Orissa and Bihar. Further, the potential in Eastern Region is about 38 per cent higher than that of Southern Region. For wheat the potential in the Eastern Region is of the same magnitude as that of northern Region.

TABLE 5.1

Rice Yield and the potential at the Optimum Dose of NPK in Eastern Region 1979-80 *to* 1981-82

State	District	No. of trials	Average yield of the district kg/ha.	Optimum does of NPK in kgs/ha			Yield at the optimum dose kg/ha.	Potential (Per cent)
				N	P	K		
Bihar	Muzaffarpur	244	789	121	60.5	60.5	4,588	481
	Purnea	184	802	152	76	76	5,511	587
Orissa	Ganjam	71	1,148	268	134	134	7,965	594
	Phulbani	119	922	438	219	219	9,306	909
Uttar Pradesh	Azamgarh	59	1,035	152	76	76	4,293	315
	Faizabad	83	984	150	75	75	4,401	347
	Jaunpur	45	1,102	279	139.5	139.5	5,481	397

TABLE 5.2

Wheat Yield and the potential at the optimum dose of NPK in Eastern Region 1979-80 *to* 1981-82

State	District	No. of trials	Average yield of the district kgs/ha	Optimum does of NPK in kgs/ha			Yield at the optimum dose kgs/ha	Potential (Per cent)
				N	P	K		
Bihar	Muzaffarpur	160	1,222	217	108.5	108.5	5,631	361
	Purnea	165	1,363	132	66	66	4,844	255
Uttar Pradesh	Faizabad	132	1,785	139	69.5	69.5	4,754	166
	Jaunpur	101	1,782	117	58.5	58.5	4,618	159
	Azamgarh	65	1,487	165	82.5	82 5	4,625	211

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TABLE 5.3

Rice yield and the Potential at optimum dose of NPK, 1979-80 to 1981-82

State	No. of trials	Average yield of the State kg/ha	Optimum dose of NPK in kgs/ha			Yield at the optimum dose kgs/ha	Potential (Per cent)
			N	P	K		
Uttar Pradesh	254	934	145	72.5	72.5	4,113	340
Bihar	428	906	134	67	67	4,964	448
West Bengal	13	1,280	80	40	40	4,967	288
Orissa	205	976	346	173	173	8,365	757
Eastern Region							*407*
Haryana	205	2,534	229	114.5	114.5	7,589	199
Himachal Pradesh	41	1,089	89	44.5	44.5	4,643	326
Punjab	180	2,851	147	73.5	73.5	6,350	123
Northern Region							*155*
Gujarat	79	1,434	71	35.5	35.5	2,736	91
Madhya Pradesh	133	813	133	66.5	66.5	5,386	562
Maharashtra	153	1,589	101	50.5	50.5	4,292	170
Western Region							*441*
Andhra Pradesh	409	2,002	125	62.5	62.5	4,862	143
Karnataka	186	1,894	108	54	54	5,625	197
Kerala	306	1,569	80	40	40	4,141	164
Tamil Nadu	631	2,09	89	44.5	44.5	4,909	135
Southern Region							*152*
All India							*323*

TABLE 5.4

Wheat yield and the Potential at optimum dose of NPK, 1979-80 to 1981-82

States	No. of trials	Average yield of the State kg/ha	Optimum does of NPK in kgs/ha			Yield at the optimum dose kgs/ha	Potential (Per cent)
			N	P	K		
Uttar Pradesh	908	1,460	141	70.5	70.5	4,389	201
Bihar	325	1,328	155	77.5	77.5	4,979	275
West Bengal	19	1,735	97	48.5	48.5	3,097	78
Orissa	791	1,859	150	75	75	2,996	61
Eastern Region							*220*
Haryana	318	2,358	175	86.5	86.5	4,755	102
Himachal Pradesh	85	1,168	119	59.5	59.5	3,713	218
Punjab	207	2,876	144	72	72	4,000	39
Northern Region							*77*
Gujarat	662	1,990	83	41.5	41.5	3,063	54
Madhya Pradesh	330	966	112	56	56	3,351	247
Maharashtra	818	891	117	58.5	58.5	2,504	181
Rajasthan	255	1,565	130	65	65	4,634	196
Western Region							*204*
All India							*167*

APPENDIX I

SELECTED EQUATIONS OBTAINED FROM STEPWISE REGRESSION ANALYSIS

Eastern Region (n=60)

$$Y_1 = 1146.79 - \underset{(2.22)}{75.06}\ MDA + \underset{(4.79)}{8540.45}\ FC + \underset{(5.63)}{0.24}\ FRO + \underset{(2.77)}{2.11}\ RM;\quad \bar{R}^2 = 0.74$$

$$Y_2 = -0.05 + \underset{(5.74)}{0.06}\ GIA + \underset{(5.46)}{0.04}\ TWA + \underset{(2.12)}{0.0007}\ SRI + \underset{(6.94)}{0.00001}\ FRO;\quad \bar{R}^2 = 0.73$$

Low Productivity Districts (n=11)

$$Y_1 = 1098.87 + \underset{(2.36)}{13659.20}\ OH - \underset{(2.85)}{2333.47}\ AOH;\quad {}^2 = \bar{R}^2.44$$

$$Y_2 = -0.01 + \underset{(20.08)}{0.03}\ TWA + \underset{(3.67)}{0.0002}\ SRI;\quad \bar{R}^2 = 0.98$$

Medium Productivity Districts (n=27)

$$Y_1 = 1293.09 + \underset{(4.38)}{5338.6}\ FC\ ;\quad R^2 = 0.41$$

$$Y_2 = 0.0004 + \underset{(4.11)}{0.06}\ GIA + \underset{(3.48)}{0.03}\ TWA\ ;\quad \bar{R}^2 = 0.60$$

High Productivity Districts (n=22)

$$Y_1 = 1360.71 + \underset{(1.90)}{612.94}\ GIA + \underset{(5.62)}{0.28}\ FRO + \underset{(2.63)}{2.31}\ RM;\quad \bar{R}^2 = 0.68$$

$$Y_2 = -0.01 + \underset{(5.63)}{0.07}\ MAW - \underset{(3.55)}{0.00003}\ ARF;\quad \bar{R}^2 = 0.64$$

NOTES—Figures in brackets denote t values
All coefficients are significant at 1 or 5 percent level of significance.

NOTATIONS

Y_1	=	Value of output per hectare (Rs.)
Y_2	=	Fertilizer use per hectare (independent variable)
FC	=	Fertilizer use per hectare (dependent variable)
FRO	=	Fertilizer retail outlets per unit of geographical area
RM	=	Regulated Market density
GIA	=	Gross irrigated area as a percent of gross sown area
TWA	=	Tubewell irrigated area as a percent of net sown area
MDA	=	Maximum drought affected area per unit of net sown area
SRI	=	Soil rating index
OH	=	Number of operational holdings above 10 hectares to total number of holdings
AOH	=	Share of area of holdings above 10 hectares to total area under all holdings
MAW	=	Male agriculture workers per unit of net sown area
ARF	=	Actual average rainfall

APPENDIX II

DETERMINANTS OF PRODUCTIVITY LEVEL AND CHANGE

To analyse the behaviour of the districts of the Eastern Region, besides analysing the states, it was also thought proper to transcend the boundaries of the state to undertake discussion on the demarcated low productive, medium productive and high productive regions because it was in the fitness of things to try to understand the cause in delineated regions, which have contributed either positively or in a negative manner to productivity levels.

The available data on the various districts was arranged under various heads, the prime among them which needed explanation pertained to the :—

(*i*) Economic and Institutional base of the districts of the Eastern Region.

(*ii*) The environmental factors to which each district was subjected and which were instrumental in determining productivity levels.

(*iii*) Technological factors, the extent of the usage of which played a crucial role in developing agriculture.

(*iv*) Management factors which judiciously combined the above inputs to improve the cropping pattern base and hence overall agricultural production.

(*v*) Infrastructural factors which were instrumental in providing input and output linkages with the market.

A number of variables on which data are available, were identified under each group to explain variation in agricultural productivity in the delineated regions.

1. Economic and Institutional factors

As mentioned in Chapter I, a high and rising pressure of population has led to a very unfavourable land-man ratio in the states of this region which is lower when compared to other states of the country and to all-India's average of 1.39. Table A-II.1 indicates that Orissa enjoys a relatively better position than the other three states of the Eastern Region where the land-man ratio is among the poorest in the country.

TABLE A-II.1

Rural population, Agricultural work force and population pressure—1981 census

State	Rural population	Agricultural work force	Rural population density	Agricultural density	Land-man* ratio
1	2	3	4	5	6
Bihar	87.5	86.7	353	5.0	0.74
U.P.	82.1	86.3	305	4.4	0.92
West Bengal	73.5	74.2	454	6.3	0.75
Orissa	88.2	81.9	150	2.9	
Andhra Pradesh	76.7	80.0	150	2.4	1.11
Gujarat	68.9	80.1	125	1.8	2.08
Haryana	78.1	76.7	229	2.6	1.82
Karnataka	71.1	80.2	138	1.9	1.59
M.P.	79.7	87.4	94	1.6	1.72
Maharashtra	65.0	82.9	133	1.8	1.59
Punjab	72.3	77.9	241	2.9	1.59
Rajasthan	79.0	82.0	78	1.0	4.00
Tamil Nadu	67.1	78.3	250	3.6	0.79
INDIA	76.7	81.1	172	2.6	1.39

Source—G.K. Chadha, "Fostering Agricultural Growth in East-Indo-Gangetic India—constraints and options". Paper submitted to Planning Commission, 1983.

*The land-man ratio is calculated in terms of agricultural workers per unit of cultivated area.

Among all holdings in each of the chosen states and the delineated regions, the share of area as well as the share of holdings below one hectare and above 10 hectares is given in the following table :—

TABLE A-II.2

Share of area and number of holdings below 1 *hectare and above* 10 *hectares* (1970's *and* 1980's)

States/Regions	<1 hectare				>10 hectares			
	Number		Area		Number		Area	
	70's	80's	70's	80's	70's	80's	70's	80's
Bihar	63.62	75.43	16.43	26.36	1.76	0.63	20.65	11.12
Orissa	43.30	46.58	11.94	15.33	1.44	1.00	12.52	9.39
East U.P.	75.34	79.22	27.71	34.35	0.49	0.28	9.14	5.39
West Bengal	59.97	65.26	21.72	27.15	0.09	0.04	4.62	3.97
Productivity regions								
Very low	47.04	56.18	10.03	10.30	3.39	2.85	20.17	26.59
Low	56.75	54.99	14.43	17.19	1.56	1.16	17.14	10.75
Medium	62.08	71.74	21.46	26.35	0.75	0.63	9.72	6.99
High	54.69	64.07	23.22	29.44	0.52	0.19	12.51	4.55
Very high	61.66	61.20	23.66	30.39	0.07	0.12	1.40	1.96
Eastern region	58.46	66.16	17.59	24.79	1.91	0.54	13.37	8.07
INDIA	50.98	54.58	10.24	10.72	3.90	2.99	35.22	26.25

In each of the states, demarcated regions and in the Eastern Region on the whole, the number as well as the share of area under this given classification of less than 1 hectare holding showed an increase and a decrease was noticed in the share of areas as well as in holdings bigger than 10 hectares. While around 60 to 65 per cent of all holdings fall under these two categories, nearly one-third of the area is covered by these two groups. For India as a whole number of marginal holdings and the area under them is lower than in the Eastern Region while that of large sized holdings is much higher.

Among the states, East U.P. has the maximum number and the largest share of area under marginal holdings, while Bihar has the largest and significant share of holdings as well as area under large sized holdings, and since productivity levels in Bihar are among the lowest in the Eastern Region, one would expect that the contribution made by these holdings is that of a minimal size. Orissa and West Bengal seem to have larger stakes in small and medium sized holdings.

The selected variables under this head, therefore, were the following :—

(1) Man-land ratio, which was specified as male agricultural workers per unit of cultivated area (x_1),

(2) Marginal holdings: This was specified both in terms of (i) ratio of holdings of less than one hectare to total holdings (x_9) and (ii) share of cultivated area under holdings of less than one hectare to total area under all holdings (x_{10}),

(3) Large sized holdings in which (i) share of holdings of more than 10 hectares to total holdings (x_{11}) and (ii) cultivated area under these holdings (x_{12}) were taken as two separate variables.

2. Environmental factors

Variety of agro-climatic base results in a variety of land-use patterns and cropping-patterns. These are also affected by a widespread variability in rainfall, frequently resulting either in floods or in droughts by which many districts are affected each year. Not only this, excessive rainfall in the catchment area, besides resulting in soil-erosion has also resulted in large scale water-logging because of clogging up of natural drainage over the years and bunding of certain areas due to the construction of roads or railway lines.

To present these phenomena, therefore, the variables specified were as follows:

(1) Average actual rainfall for the years 1970-73 and 1980-82 which represents the level of rainfall (x_8).

(2) Deviation of average actual rainfall from normal rainfall of each of the districts which represents the extent of variability of rainfall (x_3).

(3) Maximum flood affected area per unit of cultivated area during any of the three years (x_4). The maximum area was taken because it was felt that once a given tract of land is flooded, the usage of input there is a minimal nature for some years to come.

(4) Maximum drought affected area per unit of cultivated area during any of the three years (x_5).

(5) Soil-rating index which takes into consideration the depth structure and composition of soil (x_{17}).

All these variables are calculated both for 1970's as well as for 1980's for each of the districts. Since no data was available on the extent of tracts of land rendered unfit for cultivation due to water-logging, the same could not be fed as a part of the explanatory system.

3. Technological factors

Using modern devices, technology tries to fill in the resource gap due to the existence of which productivity is of a low order. Irrigational facilities, thus are of great importance in relatively water scarce regions. In the Eastern Region, nearly 25% of the net sown area of the triennium of 1970-73 and 33% of that of 1980-82 was irrigated. The share of the irrigated gross cropped area was approximately 23% and 29% respectively. The latter was lower due to the relative non-availability of water for rabi cropping.

As can be seen from the following table, the level of net irrigated area in net cultivated area is higher for the Eastern Region compared to all India but the level of gross irrigated area almost matches India's figures.

TABLE A-II.3

Share of irrigated area (1970's *and* 1980's)

State/Region	Net irrigated/ net cultivated		Gross irrigated/ Gross cropped	
	1970's	1980's	1970's	1980's
Bihar	27.52	35.47	25.58	34.41
Orissa	15.23	19.84	17.16	18.10
East U.P.	40.30	52.74	32.28	40.36
West Bengal	15.28	22.00	14.65	20.54
Eastern region	25.02	32.62	22.96	28.81
INDIA	22.57	27.66	23.46	28.61

Irrigation of cultivated area is of a much higher order for East U.P. i.e. 40% and 53% respectively during the two points of study followed by Bihar. But the level of net irrigation remained around and below 20% in Orissa and West Bengal respectively. The level of net area irrigated improves systematically as one moves from the low productive to high productive regions (Table A-II. 4). Among sources of irrigation in the Eastern Region, canals followed by tubewells have been important and their share has increased over time. Tubewell irrigated area was the highest in East U.P. among all the states where nearly 60% of the net irrigated area was irrigated by this source in 1980's.

The irrigation variable, therefore, was tried both in the form of ratios of net irrigated area to net cultivated area (x_{13}) and of gross irrigated area to total cropped area (x_{19}). However, both of them were not fed simultaneously. An additional variable formulated was the share of tubewell irrigated area in the net irrigated area (x_{14}). This was done to represent an element of controlled irrigation and its impact on productivity levels.

Besides irrigation, technological factors largely included consumption of fertilisers, use of seeds of high yielding varieties and use of mechanical inputs such as tractors, electrical engines and diesel pumpsets. The per hectare use of these inputs was not only directly related to productivity levels in each region, but it was relatively much higher for the medium and high productive regions as shown in the following table:—

TABLE A-II.4

Irrigation levels and per-hectare usage of HYV, Fertiliser and Mechanical Inputs (1970's *and* 1980's)

State/Region	Net Area Irrigated/Net Sown Area		HYV/Total Cropped Area		Fertiliser/'000 hectare cultivated Area		Tractors/'000 Net Sown Area		Diesel Pumpsets and Electric Engines/ '000ha Net Sown Area	
	1970's	1980's	1970's	1980's	1970's	1980's	1970's	1980's	1970's	1980's
1	2	3	4	5	6	7	8	9	10	11
Bihar	27.52	35.47	9.19	27.48	12.84	24.80	1.46	1.27	12.53	27.88
Orissa	15.23	19.84	3.77	16.11	7.89	12.46	0.31	0.46	1.06	7.25
East U.P.	40.30	52.74	19.48	41.64	28.75	70.96	0.91	2.44	15.14	33.00
West Bengal	15.28	22.00	17.62	22.43	14.08	50.78	0.13	0.13	1.37	1.50
Productivity Regions										
Very low	8.51	7.78	3.23	4.81	3.73	5.71	1.21	0.14	2.66	6.30
Low	19.50	11.66	9.64	13.48	13.34	10.93	0.85	0.31	7.92	7.81
Medium	32.52	32.02	14.53	29.11	19.45	31.14	0.67	1.09	9.45	19.60
High	35.87	45.03	11.72	28.62	22.22	48.13	0.12	1.79	24.89	20.36
Very high	31.42	43.15	25.62	33.63	25.88	77.71	0.10	1.02	2.44	24.93
Eastern Region	25.06	32.62	12.34	26.87	15.56	37.59	0.53	1.09	8.05	18.36
INDIA	22.57	27.66	10.96	26.11	18.35	39.32	1.06	1.93	26.69	28.02

Area under HYV is the highest in East U.P. for both the time periods, but the growth rate of this variable was the highest in Orissa followed by Bihar and East U.P. The latter two States have a relatively higher share of total cropped area under HYV compared to the average of the Eastern Region. As compared to India as a whole, performance of Eastern Region was only marginally better with respect to this variable. Consumption of fertiliser, however, was lower in this region compared to the average consumption in India. Among the various States of this Region, the quantity of fertiliser use per thousand hectares of cultivated area increased markedly in East U.P. and West Bengal but only small change was noticed in Orissa during the decade of this study.

In the 'very low' and 'low' productive regions the level of irrigation declined in 1980's, the latter region therefore, indicated a decline in the per hectare use of fertilisers. A disaggregation of mechanical input data into tractors and diesel and electricity operated tubewells indicated that while the number of tractors per thousand hectares of cultivated area declined in 1980's both for the 'very low' and 'low' productive regions, the number of pump sets and electric engines increased substantially for the 'low' productivity region. Fertiliser use seemed to follow a similar pattern. The 'very high' productivity region has a low use of mechanical inputs in 1970's largely becasuse the districts falling in this region mainly represented Eastern Uttar Pradesh, there was a marked increase in the use of these inputs.

Besides the irrigation variables mentioned above, the other formulated variables under this head therefore, were:—

(1) Quantity of chemical fertiliser used per unit of cultivated area (X_6). This variable was also separately tried in terms of one unit of total cropped area (X_{25}).

(2) Share of area under High Yielding Varieties of Various crops to total cropped area (X_7).

(3) Mechanical inputs were mainly represented by tractors alone (X_8). Pumpsets and electrical engines were not included in the final analysis because these would be highly co-linear with irrigation variables, X_{13} and X_{14}.

4. Management Factors

Better management of agricultural practices results in an improved land-use pattern alongwith a proper mix of the inputs which helps in a movement towards a more optimal and a more intensive cropping pattern leading to an increase in overall agricultural production. In the present context, these were represented in the form of:—

(1) Cropping intensity which represented the extent of intensive crop rotation followed in the various districts. For this purpose improved cropping intensity was calculated in which the area under sugarcane cultivation was added twice to indicate a two seasonal crop (X_{15}).

TABLE A.II.5

Improved cropping intensity in the Eastern Region (1970's & 1980's)

States/Regions	1970's	1980's
Bihar	131.25	135.43
Orissa	121.39	143.48
East U.P.	138.92	150.41
West Bengal	132.70	137.89
Eastern Region	131.14	141.49
India	119.57	125.65

Among the various staes the change in the cropping intensity has been of a minimal nature in Bihar and West Bengal while the other two states have shown more progress in terms of this variable.

(2) A better management of crops would mean a judicious combination of subsistence vis-a-vis cash crops. But economic rationality on part of the farmers would mean bringing a large hectarage under high valued crops, compared to low valued crops. The latter, therefore, is incorporated as a variable (X_{16}) under which crops like Rice, Wheat, Groundnut, Sugarcane, Potato and Jute were considered high valued* while the rest of them remained low-valued. In the low productive region, since the level of irrigation was lower too the share of cropped area under pulses and oilseeds was somewhat higher than other regions in 1970's. In the following decade, however, area share of rice increased while that of wheat suffered a decline. In medium and high productive regions not only larger share of acreage was under wheat but also significant positive changes were noticed in it in 1980's. These regions also had a relatively higher share of area under potato, sugarcane and groundnut.

*A crop having a higher productivity (in Rs.) compared to an overall productivity level of the Eastern Region, was considered high valued.

TABLE A.II.6

Share of high valued crops in total cropped area (1970's & 1980's)

States/Regions	Rice		Wheat		Groundnut		Sugarcane		Potato		Jute		Total of six crops	
	1970's	1980's	1970's	1980's	1970's	1980's	1970's	1980's	1970's	1980's	1970's	1980's	1970's	1980's
Productivity Level														
Very low	56.94	61.89	4.32	1.99	0.40	0.22	0.45	0.12	0.22	0.73	0.22	0.00	62.55	64.85
Low	46.81	47.18	9.69	7.55	0.33	0.40	1.32	0.45	0.84	0.60	1.94	0.64	60.93	56.82
Medium	54.27	47.85	11.16	14.67	0.35	0.50	2.35	1.31	0.75	0.86	1.61	1.67	70.49	66.86
High	37.26	51.61	15.44	14.32	0.06	0.62	2.15	1.35	1.46	0.83	1.24	2.16	57.61	71.26
Very High	61.45	50.32	10.39	12.44	—	1.22	0.93	2.31	1.79	1.87	6.79	5.01	81.35	73.17
States														
Bihar	47.81	49.36	12.56	15.24	0.04	0.04	1.37	1.01	0.97	1.13	1.26	1.33	64.01	68.11
Orissa	46.13	47.74	0.41	0.76	1.20	2.22	0.45	0.56	0.26	0.13	0.67	0.55	49.12	51.96
East U.P.	32.19	35.06	18.73	31.57	0.18	0.25	4.30	3.59	0.81	1.15	0.06	0.94	56.27	71.66
West Bengal	69.75	67.84	5.41	3.23	0.00	0.01	0.53	0.25	1.05	1.54	5.73	7.29	82.47	80.16
Eastern Region	52.89	49.64	9.85	12.87	0.31	0.62	1.69	1.33	0.80	0.98	1.84	2.12	67.38	67.56
India	22.72	23.33	11.53	12.82	4.43	4.11	1.51	1.89	0.30	0.29	0.46	0.51	40.95	42.75

Since between 55 per cent to 67 per cent of the total cropped area was covered by Rice and Wheat alone, area under these two crops (X_{21}) was tried as an alternative to the variable mentioned above. This was done because there is a close association between the productivity of rice and wheat with overall productivity. Except for Orissa in 1970's, the association of rice productivity with overall productivity is fairly high for all other states for the two time periods. The association of wheat productivity has also improved considerably for Bihar and East U.P. in 1980's while this relationship is insignificant for West Bengal in the eighties and is negative for Orissa for both the time periods.

It is , however, more important to mention that the yield of each of the crops was much higher in the medium and high productive regions. For instance, the yield or rice and wheat was double in these regions compared to the low region. The yield of potato and groundnut, was almost one and a half times higher. Except in the 'very high' productivity region, yield of sugarcane did not vary very much because in all cases it is grown under highly irrigated conditions.

5. **Infrastructural variables**

Infrastructural variables play an important role in providing accessibility to farmers to the various inputs and to the output distribution agencies. From the available data the following variables could be formulated to represent the above phenomena.

(1) Kilometres of surfaced roads per hundred square kilometeres of geographical area of the districts (X_{18}).

(2) Kilometeres of surfaced roads per lakh of population (X_{20}).

(3) Amount of loan advanced by commercial banks per unit of cultivated area of each district (X_{22}).

(4) Number of retail outlets for the distribution of fertilisers per hundred sq. kilometers of geographical area of each of the districts (X_{23}).

(5) Number of regulated markets per hundred sq. kilometers of geographicalarea of districts (X_{24}).

The data on variables X_{22}, X_{23}, and X_{24} was available for 1980's only. Hence these were tried in the explanatory system only for one point of time.

TABLE A.II. 7

Infrastructural facilities in the Eastern Region

States/Regions	Per 100 sq Kilometers of geographical area				'Bank credit per Net Sown Area 1980's
	Surfaced roads		Fertiliser retail outlets 1980's	Regulated markets 1980's	
	1970's	1980's			
Bihar	6.79	8.18	2.35	0.36	153.15
Orissa	5.37	8.62	3.00	0.03	132.98
East U.P.	10.31	20.23	6.18	0.12	142.82
West Bengal	7.15	35.12	18.62	0.32	203.50
Very low	4.80	5.96	0.61	0.30	51.57
Low	7.82	8.63	0.78	0.13	31.36
Medium	7.89	12.61	4.94	0.18	138.06
High	10.67	22.91	9.14	0.26	227.69
Very high	9.20	30.67	19.22	0.29	228.42
Eastern Region	7.00	15.02	6.00	0.21	157.23
India	12.15	16.46	N.A.	0.16	N.A.

The above table indicates that there is a higher kilometerage of surface roads available in the two high productive regions. For 1980's their average was significantly higher than both the Eastern Region as well

all-India. The discrepancy between low productive region and medium as well as high productive regions was more marked in 1980's as compared to the earlier decade. Retail outlets of fertilisers followed a similar pattern. The number of regulated markets in terms of geographical units was generally higher in Eastern Region compared to India's average. This also showed a similar trend except in the case of the 'very Low' productive region where the number per unit of specified geographical area was the highest contrary to expectations. This was primarily because of the high number in Bihar State and specifically in the classified three districts of this region. In terms of bank credit, Orissa was the poorest while West Bengal availed of this facility to a relatively higher extent and hence the level of average bank credit available in this State was higher than the average of Eastern Region. The cross-section data of the various districts was tried in a step-wise linear regression for the chosen two points of time to explain variations in productivity levels where productivity per unit of net sown area (Y) was considered as a dependent variable and all the others were considered independent variables. This analytical exercise was undertaken for (*i*) Eastern Region as a whole, (*ii*) The four states of the Region, (*iii*) The delineated high, medium and low productive regions where 'very high' and 'very low' productivity regions, were merged respectively with the 'high' and 'low' regions in order to raise the number of observations for a meaningful statistical exercise. The results of the various exercises are given in the respective tables attached. It must be mentioned at the outset that many of the variables explaining an economic phenomenon may be inter-correlated, which was also the case in this exercise as noted from the various zero order correlation matrices. Hence it was considered proper to undertake stepwise regression so that not only shifted variables are added in each step, but in the process, those acquiring weak linkages are also removed. However, the possibility of some degree of correlation in the retained variables is not ruled out. A conscious effort was made in which the obviously high correlated variables were not fed together in the explanatory system. A clear example of this is that irrigation level of net cultivated area and of total cropped area were not simultaneously fed. Similarly, consumption of fertiliser per unit of net and of gross cultivated area were tried separately. Further, it was also attempted to try number of holdings and area of holdings of the two sized groups in different sets too, besides a combined exercise. Similarly, kilometerage of surfaced roads per specified unit of geographical area or of population were fed in two different combinations. One would presume a high degree of correlation between the quantity of fertiliser consumed and the number of retail outlets too, but since the latter was one of the indices of the infra-structural development, it was retained alongwith the former. Yet in another combination, the variable representing High Yielding Variety seeds was opted out to reassess the equation when one of the two highly correlated variables is removed. Under such circumstances, invariably consumption of fertiliser provided the maximum explanation. It may also be noted that except for surfaced roads, data for other infra-structural variables was available for the eighties only and hence these could not be tried for 1970's. To turn to the specific region-wise equations, the overall productivity level in the Eastern Region (Table-A-II. 8) in 1970's was positively and significantly affected by the usage of High Yielding Variety seeds, cropping-intensity, and share of acreage under Rice and Wheat crops. Connectively through surfaced roads also indicated a positive impact but with a relatively lower level of significance. Tractorisation comes with a negative sign for both the time periods. A scrutiny of the data reveals that while some of the high ranking West Bengal districts have lower number of tractors, the low productive districts of Bihar & Orissa have a relatively higher number, giving an overall increased relationship. For the interpretation of negative signs of X_9 and X_{14}, a close look at the zero order correlation matrix suggests a positive behaviour of these variables with the dependent variable, but since there exists a fairly significant correlation between X_9, X_{14}; X_{14}, X_{15}; and X_{14}, X_{21}; after the effect of the first four steps is eliminated, the relationship of the dependent variable with the remaining steps comes out negatively. To overcome this problem, therefore, to choose the final equation (*ii*) it was thought proper to stop at point where the last three steps are not included. By doing so, the R^2 gets a little lowered to 73 per cent from 77 percent and the extent of explanation lost is not of a high order. In any case nearly three-quarters explanation is found in the retained variables.

Environmental variables like area under floods and drought had a negative impact on productivity levels. In 1980's also, irrigation quality variable (X_{14}), i.e. area under tubewells responds in a negative fashion in the step regression. Like the earlier decade again the variable was seen to be correlated with cropping-intensity (X_{15}), the extent of correlation being 0.5073 which is significant for 60 observations. Hence, although X_{14} shows a positive relation with productivity levels in the correlation matrix, as soon as it enters after the entry of X_{15}, it brings forth an unexpected sign. Therefore, for the final equation (*ii*) only the first three steps were taken into consideration which explain 83 per cent of the total variation in productivity levels of the Eastern Region as a whole.

To further elaborate on this Region, the state-wise results indicate (Table-A-II. 9) that common characteristics like usage of fertilisers feature importantly, being positively related to productivity levels in Bihar for both the time periods of study. Variability of rainfall formulated in the form of deviation of actual rainfall from the normal is represented with a plus sign in the equation of 1970's clearly specifying that districts where actual rainfall deviates negatively from the normal rainfall, the productivity tends to be low and vice versa. Variable X_{20} i.e. kilometerage of surfaced roads per lakh of population did emerge in the equation of Bihar in 1970's but it had a negative sign. This was because the relatively high productive districts of these states having higher infra-structural facilities in spatial terms also happened to be more population dense regions where the man-land ratio was relatively lower, hence the variable specified in this form was inversely related with the dependent variable. To overcome this problem, the model was re-run by dropping X_{20} and thus the second equation was obtained for the State. It is seen that in addition to the two variables explained above, cropping-intensity emerged as a new variable affecting productivity levels

positively. Both these equations explain more than 80 per cent of the variations in productivity levels in 1970's. In 1980's the explanatory power increased to a little over 90 per cent as is clear from the equation, when two variables indicating tractorisation and acreage under high valued crops like Rice and Wheat are added to the already importantly emerging variables like fertiliser application and cropping-intensity due to an increase in which, productivity increased too.

Since fertiliser consumption emreged as an important variable in both the periods, and as other variables like area under HYV, level of net/gross area irrigated-tubewell irrigation, share of area under marginal holdings and tractorisation, were all significantly and positively correlated with fertiliser variable in 1970's and hence these were not captured by the final equation. In 1980's, however, tractorisation is the most significant variable followed by share of acrerage under rice and wheat crops. Soon after the effect of these two variables is eliminated after the second order partial correlation matrix, fertiliser consumption and cropping intensity variables enter into the equation. In Orissa, intensity of cropping is a significant variable explaining productivity variations in both the time periods. In additon to this, high variability of rainfall gives lower productivity in 1970's. The basic data indicates that the extent and area spread of negative deviation from the normal rainfall is quite high in this state. The higher this variability, the lower is the productivity. Number of tractors which have a high association with share of acreage under large sized holdings directly influence productivity alongwith acreage under holdings 1 hectare while the quality variable of irrigation is inversly related. This is because in the coastal and the relatively high productive districts, canals are the major source of irrigation. For example in Cuttack, Puri, Sambalpur and Ganjam, the only four districts falling under medium productivity classification in 1970,* the share of net area irrigated by canals was 91%, 80%, 76% and 42% respectively. Since variables X_6 and X_{15} (i.e. fertiliser consumption and cropping intensity) are positively correlated while X_3 and X_7 (rainfall variability and HYV) are inversly and significantly related, both X_6 and X_7 were not picked up in the set of equations in which acreage of the two sized holdings were fed. But acreage under the chosen small sized holdings was listed positively in the equation. In yet another attempt where only the variables representing number of holdings were fed with other variables, HYV alongwith the number of small sized holdings does turn out significantly and positively explaining variation in productivity levels. In 1980's as mentioned earlier, besides X_{15}, fertiliser retail outlets among infra-structural and HYV among technological variables emerged significantly while level of net irrigagation came with a negative sign but was insignificant. Therefore, if this last step is omitted, the explanatory power drops only marginally from 95% to 93%.

Eastern Uttar Pradesh has fertiliser consumption significantly explaining productivity variations in 1970's alongwith ratio of surfaced roads to geographical area of the various districts. As in Orissa, variability in rainfall has a dampening effect on productivity levels. In an alternate equation when utilisation of fertiliser per unit of gross cropped area is tried and when area under floods enters with a high value and a negative sign, variable representing fertiliser (X_{25}) gets removed and in the chosen equation, employment of male agricultural workers and cropping-intensity are other important variables positively influencing the dependent variable.

As indicated by the first equation, in 1980's the two infra-structural variables i.e. bank credit availability and the number of fertiliser retail outlets together provide more than 80 per cent of the explanation in productivity variation across the districts of the state. Alternatively, when irrigated area under all crops alongwith other variables was fed in the system, the explanatory power increases to a little more than 90 per cent with

TABLE A. II. 8

Regression results of productivity levels of 1970's and 1980's

		Degrees of Freedom	$\bar{R}^2$
Eastern Region			
(*i*) Y 1970=	$-104.538086+2251.957275\ X_7-184.215561\ X_8-488.324951\ X_9$ (0.18) (4.87) (2.58) (1.93) $-435.029053X_{14}+1428.246094X_{16}-170.286530X_{17}+27.360306\ X_{19}+888.631104\ X_{21}$ (2.20) (5.08) (2.68) (2.30) (4.03)	51	0.77
(*ii*) Y 1970=	$-34.481445+2309.99145\ X_7-251.155472\ X_8+1222.218262\ X_{16}-15.704491\ X_{17}$ (0.06) (5.38) (3.38) (4.18) (2.27) $+881.341797\ X_{21}$ (4.18)	54	0.73
(*i*) Y 1980=	$-849.914307-308.555420\ X_4-42.331131\ X_5+6879.277344\ X_6+751.071777\ X_7$ (2.47) (1.71) (1.83) (5.78) (2.85) $-67.304657\ X_8-646.736572\ X_{14}+1349.281494\ X_{16}+369.757080\ X_{21}$ (2.44) (4.74) (6.50) (1.62) $+0.144306\ X_{23}+1.848330\ X_{24}$ (4.00) (3.50)	49	0.90
(*ii*) Y 1980=	$-125.038498+1157.884521\ X_6+200.83276\ X_{15}+0.37032\ X_{23}$ (0.43) (4.15) (4.60) (7.07)	56	0.83

NOTE—Figures in parentheses are the t-values.

TABLE A. II.9

Regression results of productivity levels of states of the Eastern Region, 1970's and 1980's

		Degrees of Freedom	$\bar{R}^2$
Bihar			
(*i*) Y 1970=	$1302.008301+1.054416\ X_3+26615.125000\ X_6-14.297378\ X_{20}$ (9.37) (3.30) (5.85) (2.64)	11	0.83
(*ii*) Y 1970=	$-207.(317871+1.011884\ X_3+29355.332031\ X_{25}+957.781006\ X_{15}$ (0.37) (2.89) (2.82) (2.27)	11	0.80
Y 1980=	$-281.068359+5606.78156\ X_6+131.164810\ X_8+567.165527\ X_{15}+806.639898\ X_{21}$ (0.60) (2.27) (3.07) (1.82) (2.66)	10	0.91
Y 1970=	$-410.824707-0.912786\ X_3+205.210587\ X_8+1942.714600\ X_{11}$ (1.65) (6.39) (2.17) (4.35) $-2384.968750\ X_{14}+130.283447\ X_{15}$ (3.82) (5.13)	7	0.96
Orissa			
(*i*) Y 1980=	$-195.261963+2747.620117\ X_7-996.539551\ X_{13}+749.313721\ X_{15}+0.914577X_{22}$ (0.55) (4.29) (1.97) (3.29) (5.33)	8	0.95
(*ii*) Y 1980=	$166.502289+1938.35913\ X_7+507.384033\ X_{15}+0.678876\ X_{23}$ (0.51) (3.43) (2.30) (4.79)	9	0.93
East U.P.			
(*i*)Y 1970=	$479.3724268-0.511911\ X_3+10276.65234\ X_6$ (3.53) (2.81) (4.16) $+33.958878\ X_{16}$ (3.31)	11	0.83
(*ii*) Y 1970=	$-1257.084717+631.650391\ X_1-512.833984\ X_4$ (2.22) (3.56) (5.82) $+1287.729980\ X_{15}$ (3.41)	11	0.89
(*i*) Y 1980=	$861.042969+1.751973\ X_{22}+0.825716\ X_{23}$ (5.31) (2.17) (5.34)	12	0.81
(*ii*) Y 1980=	$-643.235107+0.275185\ X_3+788.92163\ X_{15}$ (0.94) (2.08) (1.89) $+1444.711914\ X_{19}+1.176772\ X_{22}+0.419318\ X_{28}$ (2.85) (1.63) (2.34)	9	0.9
West Bengal			
Y 1970=	$1212.323242+0.079790\ X_2-287.522217\ X_4$ (5.56) (2.92) (3.36) $+16879.527344\ X_6+2086.966797\ X_7+1315.167480\ X_{18}$ (5.49) (4.66) (10.99) $+750.956055\ X_{21}$ (5.56)	8	0.99
Y 1980=	$704.093506+5555.378906\ X_6+4162.113281\ X_7+2.276987\ X_{24}$ (3.73) (2.79) (4.86) (3.32)	11	0.91

*No district of Orissa was classified as high or very high productive district in 1970's.

cropping intensity, total cropped area irrigated and rainfall variability appearing with positive signs. Besides the given equation, from the correlation matrix it is amply clear that area under floods and drought have a negative association with productivity levels. Technological variables like fertiliser ocnsumption and area covered under HYV are not picked up because of high association of 0.7655 between the former and cropped area irrigated; between fertiliser quantity and its retail outlets (0.7853) between HYV and total irrigated area (0.5594) and between HYV and cropping-intensity (0.4802).

In *West Bengal*, many districts indicated high productivity levels in 1970's itself which was indicated in Table-2.3. Unlike East U.P., it is not a high growing state in terms of productivity, but the districts of 1970's were able to retain their high productivity level in 1980's too. Therefore, probably fewer districts have undergone a reshuffle in this state. From the equations of both 1970's and 1980's it is noticed that share of area under HYV has emerged as a significant variable.

When combined with cropping-intensity in the second step, the explanatory power of the equation increased to 91 percent. Fertiliser consumption and the level of net irrigated area and share of area under high valued crops like rice and wheat entered successively in the following steps affecting productivity levels positively. But when area under floods enters in the last steps with a negative sign, irrigated area shows weak linkage and is removed thereby. However, full explanation is captured by the noted variables for this point of time. In 1980's technological factors like HYV (which is one of the most significant variables in this state) and fertiliser enter significantly alongwith regulated market variable, to explain more than 90 per cent of the total variations in productivity. In the following steps of this chosen equation, area under floods enters with a positive sign but since its value was not significant, the equation given in the table was retained as final. When HYV was dropped and the equation re-estimated the role of fertiliser is doubly enforced and a high t-value makes it a much more influential variable. In this equation X_{20} (surface roads per lakh of population) comes with a negative sign. In still another attempt when X_{20} is dropped while all the other variables are retained, HYV and agricultural male workers, alongwith variable depicting bank credit enters importantly in the explanatory system of the productivity levels of 1980's. In this state also fertiliser is highly correlated with irrigation variable with share of area under marginal holdings, tractorisation, fertiliser retail outlets and variable HYV having close association with irrigated areas and with fertiliser sale points. Hence many of these variables are not picked up in the relevant equations. These given variables together had an $\bar{R}^2$ of 91 per cent taking care of most of the cross sectional variations as shown by the data.

The *High productivity region* of 1970's largely consisted of the districts of West Bengal and hence the analytical outcome was similar to the results of the state where HYV emerged as the dominant variable. In this region also, HYV alone explained 89 per cent of the variations in productivity when it entered as step one. In the two successive steps area under wheat plus rice and under floods came with a negative sign. With an addition of these two variables, the explanatory power increased to 96 per cent. But since HYV (X_7) and area under wheat and rice (X_{21}) were highly correlated (.7198) the latter appeared with a wrong sign. Hence the retained equation appears with only HYV co-efficients.

In 1980's fertiliser retail outlets and number of regulated markets emerge for more significantly. These combined with HYV provide 68 per cent of the explanation.

Districts belonging to the *medium productivity region* in 1970's, pointed towards the role of cropping-intensity in raising productivity. As expected, number of marginal holdings had a negative contribution in raising productivity while the latter increased where deviation of rainfall was positive and vice versa. When among all variables the area under marginal and large-sized holdings are fed instead of their number, the explanatory power of the equation increased from 54% to 62% with area under marginal holdings and share of area jointly under Rice and Wheat emerging as positive variables explaining productivity differentials. The number of agricultural male workers per unit of cultivated area showed a negative relationship indicating that pockets having worker concentration had lower productivity levels.

The following decade experienced a more emphatic role being played by the technological variables such as fertiliser consumption and area under HYV. While net area irrigated, controlled irrigation through tubewells and mechanical input in the form of tractors were all positively correlated to the dependent variables as seen in the zero order correlation matrix, they entered with a negative sign in the given equation because of high inter-correlation between the various variables of this equation as noted below :—

Variables	Correlation
X_6, X_{13}	0.7228
X_6, X_{14}	0.6626
X_7, X_{13}	0.5102
X_7, X_{14}	0.6345
X_8, X_{13}	0.5805
X_8, X_{14}	0.5406
X_7, X_8	0.7194
X_6, X_8	0.6149

If these steps were excluded from the final equation, the extent of explanation fell considerably. Therefore, these were retained and all the above mentioned variables together with the positive role of acreage share of rice and wheat explained nearly three-quarters of total variations in productivity levels.

The *low productivity region* of 1970's offers a conundrum to the analysis where among the 23 variables fed in 1970's a lone variable X_{18} (kilometerage of surfaced roads measured in terms of geographical area) is picked up by the regression equation and this variable can

TABLE A.II.10

Regression results of High, Medium and Low productive Regions of the Eastern Sector, 1970's and 1980's

		Degrees of Freedom	$\bar{R}^2$
High productivity region			
Y 1970=	1307.443604+3814.916260 X_7 (11.72) (8.21)	11	0.89
Y 1980=	1344.441406+775.193604 X_7+0.276676 X_{23}+2.383931 X_{24} (7.65) (1.77) (5.44) (2.67)	19	0.68
Medium productivity region			
(*i*) Y 1970=	992.831787+0.329360 X_3—934.458496 X_9+789.641846 X_{15} (3.35) (3.78) (4.93) (3.97)	21	0.54
(*ii*) Y 1970=	391.482666—222.306747 X_1+0.350115 X_3+520.824219 X_{12}—220.772583 X_{13} (1.38) (3.54) (3.66) (2.30) (2.24) +844.704346 X_{15}+349.997559 X_{21} (4.57) (2.25)	18	0.62
Y 1980=	1055.699951+5695.375000 X_6+641.422607 X_7—62.887436 X_8—279.024170 X_{13} (10.29) (5.47) (4.07) (2.71) (2.57) —198.184357 X_{14}+342.000244 X_{21} (2.46) (2.94)	20	0.73
Low productivity region			
Y 1970=	887.581543+15.605322 X_{18} (16.99) (2.34)	24	0.15
Y 1980=	1098.866699+13659.195312 X_{10}—2333.469238 X_{12} (7.89) (2.36) (2.85)	8	0.44

explain only 15 per cent of the total variations. No other specified variable is associated with productivity levels in a significant manner. It is possible that other infra-structural variables, data on which was not available for 1970's, perhaps could add to the explanatory power. Also more specified information on tenancy and on fragmented holdings perhaps could offer higher explanation.

In 1980's, agricultural structure variables were picked up by the equation and in a combined run of holdings' number as well as area, while the number of holdings above 10 hectares was positively related with the dependent variable, the share of acreage under these in total holdings' acreage had a negative impact which means districts where the area share under large holdings was high, overall productivity levels were low. Since these holdings are being used as a proxy for tenancy, low productive areas, as mentioned in Table-A-II. 2 too, have a higher share of area under large sized holdings thus having an inverse relation with productivity levels.

At the state level and for the Eastern Region as a whole for both the time periods (except for West Bengal in 1980's), crop management represented in the form of cropping-intensity enters as the most frequently significant variable explaining inter-district variations in productivity levels. Fertiliser consumption is important for both the points of time for Bihar and West Bengal while area under HYV is significant for West Bengal for 1970's as well as for 1980's. For Orissa it is important only for the latter period. It must be mentioned at the outset that a strong positive correlation exists between the use of fertiliser and area under HYV because the former is largely used where new and better quality seeds are sown. Similarly, both of them are highly and positively associated with area under irrigation. The latter, however, also has a strong association with the cropping-intensity variable which has been significant for all regions. Due to these reasons, either quantity of fertiliser or area under HYV were picked up in the various equations and except for East U.P. in the 80's, in other states irrigation variable remained at the background though it has always shown a significant positive correlation with the dependent variable. Wherever both quantity of fertiliser consumed and area under HYV have entered the chosen equation, the level of significance for each has been relatively lower compared to when only one of these has appeared. Many inter-correlations are seen in economic phenomena and among these, share of area under rice and wheat is seen to be consistently and directly related to cropping-intensity in a significant manner. By the same token it has also been positively related with productivity levels particularly in districts of Bihar (1980), West Bengal (1970) and for Eastern Region for both the time periods undertaken for this study. When infra-structural variables were fed alongwith others for 1980's they usually helped not only in enhancing the explanatory power but have also appeared very significant. Among the environmental factors wherever variable representing flood area has entered, it has carried an expected negative sign with it. Variability of rainfall has emerged frequently in Bihar, Orissa and East U.P. for the earlier decade and for East U.P. for the latter. This variable can be interpreted both ways. When emerging with a negative sign, a high extent of variability in the form of negative or positive deviation from average

normal rainfall means lower productivity. This variable, has in many cases appeared with a positive sign too. This has usually happened when the extent of deviation from normal rainfall is not too high, with the result, the districts where there is slightly higher than normal rainfall, produtivity levels are higher and vice versa. This has happened in Bihar (1970's) and in East U. P. (1980's).

In the various productivity regions explanation for the high productive districts has mainly been represented by variations caused in acreage covered by High Yielding Varieties in 1970's and this alongwith number of fertiliser retail outlets and regulated markets was significant in the latter decade. This was so because of the high weightage provided by the districts of West Bengal which behaved similarly. The Medium productive regions had cropping-intensity alongwith share of area under Rice and Wheat crops appearing with a positive sign in the 70's while the latter variable alongwith consumption of higher fertiliser quantity and larger HYV area was important in the 80's. This is apparent because these inputs alongwith irrigation are largely used for superior cereal crops. Rainfall variability has also partly explained productivity differntials both in the high and medium productivity regions. But none of the expected variables turn out importantly for the low productive region and hence it offers a low level of explanation in 1970's. Agricultural structure variables, however, provide an expected pattern in 1980's in this region. But more importantly, as is indicated from the various input tables prepared for the delineated regions, it is amply clear that the low productive regions have relatively a large hectarage covered by large sized holdings where problems associated with tenancy cannot be ruled out and which can act as an impediment to input use. The latter gets reflected not only in lower consumption of fertilisers, area under HYV or low irrigation base, but this region is poor in terms of infrastructural facilities too. These facilities as well as technological inputs are seen to be directly related as one moves from low productive region to the high productive region. The two low productive regions also happen to have a higher area covered by drought conditions. Therefore, lower level of productivity can be attributed to an ensemble of these factors. From the analysis it is also apparent that a high cropping intensity alongwith a high share of area under Rice and Wheat crops also contributes positively in raising productivity levels because a major share of inputs is also commanded by these crops.

Hence, while for the High and Medium productive regions further intensification of crop rotation alongwith a support of technological inputs particularly for high valued crops, and infra-structural facilities will help to further raise productivity levels, more long-term measures are sought to increase productivity in the districts of the low productive region. For instance, the whole problem of the agricultural holdings structure needs to be looked into and while necessary measures are required for the drought and flood areas, these have to be combined with broadening the base of technological inputs and infra-structural facilities. More than that to bring them at par with the current medium and high productive regions, sufficient agricultural extension work is needed through which knowledge is imparted to the farmers regarding crop management and crop intensification which necessarily means an effort to optimise the use of available resources as well as inputs.

List of Variables

(*i*) *Dependent Variable*

Y=Productivity (in Rs.) per unit of Net Sown Area

(*ii*) *Independent Variables*

X_1= Male Agricultural Workers per unit of net sown area.

X_2= Actual Average Rainfall.

X_3= Deviation of actual average rainfall from Normal rainfall.

X_4= Maximum area affected by floods per unit of net sown area.

X_5= Maximum drought affected area per unit of net sown area.

X_6= Consumption of Fertiliser per unit of net sown area.

X_7= Share of area under High Yielding Varieties in total cropped area.

X_8= Number of tractors per '000 units of cultivated area.

X_9= Ratio of holdings<1 Hectare to total holdings.

X_{10}= Ratio of holdings > 10 Hectares to total holdings.

X_{11}= Share of Area of holdings < 1 hectare in total area under all holdings.

X_{12}= Share of area of holdings > 10 hectares in total area under all holdings.

X_{13}= Ratio of net irrigated area to Net Sown area.

X_{14}= Share of tubewell irrigated area in net irrigated area.

X_{15}= Improved Cropping-intensity.

X_{16}= Ratio of Area under the selected six high valued crops to low valued crops.

X_{17}= Soil Rating index.

X_{18}= Kilometers of surfaced roads per 100 sq. kilometers of geographical area.

X_{19}= Ratio of Gross irrigated area to Gross Sown area.

X_{20}= Kilometer of surfaced roads per lakh of population.

X_{21}= Share of area under Rice and Wheat in Total Cropped Area.

X_{22}= Commercial Bank loan per unit of Sown area.

X_{23}= Fertiliser retail outlets per unit of geographical area.

X_{24}= Number of regulated markets per unit of geographical area.

X_{25}= Consumption of Fertiliser per unit of total cropped area.

APPENDIX III

IMPACT OF CONSOLIDATION OF HOLDINGS*

The impact of consolidation of holdings on agricultural production presented below is based on an evaluation study of Azamgarh distirct of east U.P. The reference year of the study was 1978-79. The study was based on a sample of 50 farmers from five villages where consolidation of holdings was not done and another sample of 50 farmers from five villages where consolidation of holdings was completed some years back and its benefits were stabilised. Two stage startified random sampling method was used for selecting the sample farmers. The two sample of villages belonged to two different tehsils whose agro-climatic characteristics were broadly similar. The average size of cultivated area on unconsolidated holdings was 4.10 acres fragmented into 5.5 plots of 0.84 acre each on average. Only 8 per cent of such holdings had two plots or less. On the other hand, the average size of cultivated area on consolidated holdings was 3.29 acres distributed into 3.1 plots of 1.08 acres each. The percentage of such holdings having their land distributed into 2 plots or less was 80. An average consolidated holding had invested Rs. 1,685 in tubewells as compared to only Rs. 666 by unconsolidated holdings. The percentage of net sown area irrigated on consolidated holdings was more than 90 as compared to about 50 on unconsolidated holdings. It is striking to note that almost the entire irrigation on consolidated holdings was done by tubewells. This is not because every farmer with consolidated holding had installed tubewell but because the number of tubewells had increased substantially after the consolidation of holdings and these alongwith state tubewells provided irrigation to farmers having no tubewells of their own. Consolidation accompanied by higher extent of irrigation appears to have good impact on intensity of cropping and the value of land. The intensity of cropping was 179.39 per cent and the value of owned land was Rs. 8,954 per acre on consolidated holdings as compared to 150.71 per cent and Rs. 6,375 per acre, respectively on unconsolidated holdings. This indicates that consolidation by creating conditions for higher investment in land initiates farmers to borrow more. The adoption of improved practices of cultivation and improved implements was far more higher on consolidated holdings as compared to unconsolidated holdings. As a result of all these, yield per acre in different crops was higher on consolidated holdings than unconsolidated holdings.

The valuc of output is almost double and profit is almost three times higher on consolidated holdings as compared to unconsolidated holdings. On the other hand, cost of cultivation per cultivated acre is almost the same on the two group of holdings. The latter has been possible mainly because of lower cost of cultivation of bullock labour, human labour and seed inspite of substantially higher cost of machine labour and manure and fertiliser on consolidated holdings as compared to unconsolidated holdings.

The analysis indicates very high benefits from the consolidation of holdings. The incremental income arising due to it was found to be more than a thousand rupees per acre of cultivated area in 1978-79 in a district of east U.P. The consolidation of holdings needs to be done as early as possible, particularly in areas where ground water potential is good and consolidation of holdings is feasible. The consolidation of holdings would provide tremendous boost to private investment in irrigation which in turn would lead to adoption of new technology of crop production particularly in rabi and summer seasons. The problem of drainage would also be mitigated, to a certain extent, because of provision of land for the purpose through the process of consolidation. The combined efforts of all these would be substantial increase in productivity of land. This is what has taken place in east U.P.

*Adopted from the unpublished paper "Some Aspects of the Strategy of Agricultural Development in Eastern Region of India" by J.P. Singh.

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